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LEEDS
GEOLOGICAL ASSOCIATION.

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S. A. ADAMSON, F.G.S.,

Late Secretary Leeds Geological Association

1890.

TRANSACTIONS

OF THE

Leeds Geological Association,

CONTAINING ABSTRACTS OF THE

PAPERS READ,

AND

REPORTS OF FIELD EXCURSIONS

TAKEN, DURING

1889.

PART V.

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OUR PORTRAITS.—No. 2.

THE LATE MR. S. A. ADAMSON, F.G.S.

IN issuing to the Members of the Leeds Geological Association the Fifth Part of our Transactions, the Council have to record with the deepest regret the decease of the one by whose pen most of its contents were written, and whose untimely death has deprived our Association of a valuable officer and self-denying worker. Our late Secretary, to whose untiring zeal much of the success which has attended our Association has been due, just as he was arranging for the publication of these Transactions, was seized by the influenza, followed by a severe attack of pleurisy, which brought his useful and active life to an untimely close (13th March, 1890).

By Mr. Adamson's death not only has our own Association sustained an irreparable loss, but Geological Science, especially in Yorkshire, will miss a most enthusiastic worker, and one whose contributions to the pages of geological literature were widely known and esteemed.

Samuel Arthur Adamson was the son of Mr. Joseph Adamson, former gas manager at the Leeds New Gas Company before its purchase by the Corporation. He entered the office of the Gas Company as a boy twenty-nine years ago, and gradually rose until he attained the position of chief clerk. Taking a deep interest in natural science, he attached himself to the geological class at the Yorkshire College, under the tutorship of Professor A. H. Green (now of the University of Oxford), and was a constant attendant at the excursions conducted by that gentleman, profiting by the thoroughly practical teaching there conveyed, and learning his physical geology in the only place where it can be effectively studied—namely, in the field. He made a special study of the Coal Measure, Liassic, and Oolitic formations, all of which are well developed in Yorkshire. Frequent evidence has been given of his accurate knowledge and painstaking work in the numerous contributions which he made to our local papers. His poetical and interesting treatment of the hard facts of science made the records of our meetings and excursions most attractive not only to our members but even to large numbers of unscientific readers. There was also a vein of humour, of the quiet and sympathetic kind, in his nature, and many a quaint expression has alleviated the tedium of the homeward march after a long and tiring tramp.

Mr. Adamson had also a very practical side to his character, and no one knew better than he that it is only by hard and continuous effort that interest in a good cause can be generated and extended. He was ever most energetic in the spread of scientific knowledge; and even in remote localities, and perhaps not under the most favourable circumstances, his enthusiasm spread to those who were for the time his associates. Many a small society has been stimulated to activity by his advice and example, and not a few have owed their existence in a large measure to his initiative.

Mr. Adamson was a valued member of many scientific societies. A visit which our Association paid to investigate the history of the Hitching-stone, an isolated block of gritstone on the moors five miles west of Keighley, led to the formation of the Yorkshire branch of the Erratic

Boulder Committee, of which Mr. Adamson became honorary secretary. He occupied the office of honorary secretary to the geological section of the Yorkshire Naturalists' Union; the proceedings of that section as published, were written by him. As a member of the committee appointed by the British Association for the Collection, Preservation, and Systematic Registration of Photographs of Geological Interest in the United Kingdom, Mr. Jeffs, the secretary of the committee, found Mr. Adamson's practical knowledge and effective support of the greatest value; he was also a vice-president of the local committee.

Mr. Adamson was the local secretary for the Leeds district and a member of the Council of the Yorkshire Geological and Polytechnic Society. He has published papers in its "Proceedings." He described sections which had been revealed by the excavation of a gas-holder tank near Barnsley, consisting of silt, gravel, and clay, resting on Middle Coal Measures, and containing the remains of beetles, fresh water shells, and plants. In the same gravel a remarkable implement was found, composed of mica-schist, smooth, and having at its sides peculiar groovings which had evidently been produced by man. The formation of a line of railway from Ilkley to Skipton afforded Mr. Adamson an opportunity of studying the contorted limestones and shales of that district, and the superincumbent glacial beds. A description of these beds formed the subject of a paper to the Polytechnic Society, which was published. He also contributed papers to the Geological Society of London, of which he was a Fellow; to the British Association, whose meetings he regularly attended; and to local societies, on a variety of subjects, perhaps the most important being on the discovery of fossil tree roots and stems at Clayton, in the Lower Coal Measures. No excursion of the Leeds Geological Association, or of the Yorkshire Naturalists' Union, was complete without his genial presence. It was expected that he would have taken a very active part in the next meeting of the British Association, which is to be held in Leeds, and his loss will, on that occasion, be much felt. His kindness and geniality made him a great favourite, and his loss leaves a gap in our fellowship which it will be indeed hard to fill up.

The following letter of condolence was sent to Mrs. Adamson by the Committee.—

"Dear Mrs. Adamson.—"It is with feelings of the deepest sorrow "that we learn of the death of Mr. Adamson. For the few years that "this society has been in existence we have all learnt to value your "husband's connection with it, and to appreciate his private worth. His "genial and engaging manner has been an attraction to all of us, and "since he undertook the onerous duty of secretary, the society has come "much more prominently under public notice. This we all attribute "almost entirely to his untiring efforts and to the power with which he "wielded his pen, making clear and interesting a subject which has often "been looked upon as uninteresting and pedantic. To us, as geologists "and friends, his loss will be great, and we offer you our deepest "sympathy in your irreparable bereavement.

"Signed on behalf of the Council Members of the Leeds Geological "Association. J. E. BEDFORD."

Our members will be glad to learn that a subscription has been organised for the benefit of Mr. Adamson's widow and four children. It is hoped that a sum of £250 will be raised.

REPORT

FOR THE YEAR ENDING JUNE 20th, 1889.

THE COUNCIL present the FIFTEENTH ANNUAL REPORT with much pleasure, as they feel sure it shews that the Association has passed through another year of usefulness and prosperity.

MEMBERSHIP.

The number of members still continues to advance in a most gratifying manner; a reference shews that the roll which stood in 1884 at 30, and had increased regularly to 109 in 1888, now registers 130 members.

MEETINGS.

There have been eight evening meetings of the Association. The inaugural address of the PRESIDENT (Mr. J. E. Bedford, F.G.S.) dealt with one of the most valuable products of the mineral world, Petroleum, and the localities where it is obtained: he also gave an account of the discovery and development of natural gas.—Mr. W. CHEETHAM favoured the members with a thoroughly interesting description of a recent tour in North West Yorkshire in a paper entitled "From the Millstone Grits to the Silurians."—Mr. HOLGATE, F.G.S. in his "Notes on the Lake District" gave the Association the benefit of his observations on a visit to Keswick, accompanied by the exhibition of a large number of specimens of the varied rocks of that district.—Mr. JOHN INGLEBY, in his paper on "Ceylon's Isle," gave a most valuable account of the history, meteorology, physical geography, and geology of that beautiful island: the paper was further enhanced by the views which had been taken in Ceylon by the lecturer being thrown upon the screen by Mr. G. Bingley.—Mr. WASHINGTON TEASDALE, F.R.A.S. most kindly gave an evening devoted to the exhibition and description of a large number of photographic lantern slides, illustrating palæontology, geology, and former excursions of the members.—The paper by Mr. C. D. HARDCASTLE on "The Physical Features of Ingleton" will be long remembered as the most practical and detailed account of that district yet given, being likewise illustrated by maps, diagrams, and a large number of specimens which the author had personally obtained from the sections described.—At the next meeting the members

had the privilege of hearing, in the Philosophical Hall, a first class palæontological lecture by Mr. A. SMITH WOODWARD, F.G.S., of the British Museum (Natural History), the subject being "The Application of the Laws of Comparative Osteology to the Palæontology of the Vertebrata;" this lecture was also illustrated by the lantern.—The closing lecture was by Mr. FITTON, who in his paper entitled "One of Nature's Gems," gave a detailed account of that chief of earth's treasures, Coal, illustrated by a large number of specimens.—The members will observe that although no night had been specially set apart, as heretofore, for the exhibition of specimens, yet at nearly every meeting large numbers of specimens bearing directly upon the subject of the evening, have been exhibited and closely studied.

EXCURSIONS.

The excursions in the field have during the last session received the close attention of the Council, who recognise that to these must be attributed largely the prosperity of the Association.

	DISTRICT.	LEADER.	GEOLOGY.
No. 1	Knaresbro' to Nidd Bridge	Mr. B. Holgate, F.G.S.	Permian
„ 2	Beeston and Batley Railway	Mr. W. Bowley, C.E., F.G.S.	Middle Coal Measures
„ 3	Robin Hood's Bay	Mr. W. H. Huddleston F.R.S.	Oolite and Lias
„ 4	Market Weighton	Rev. E. M. Cole, M.A. F.G.S.	Lias and Cretaceous
„ 5	Garforth & Newthorpe	Mr. B. Holgate, F.G.S.	Permian
„ 6	South Milford and Sherburn	Ditto	Do.
„ 7	Brough and Elloughton	Ditto	Tertiary Gravels & Oolites
„ 8	Giggleswick & Langcliffe	Mr. W. G. Perfect	Mountain Limestone
„ 9	Haddockstones and District	Rev. J. S. Tute, B.A.	Erratics, Permian and Third Grits
„ 10	Holme Valley	Mr. J. Field	Millstone Grits

The members will thus observe that the localities have been carefully selected, giving splendid facilities for studying in the field, under accomplished and practical leaders, the geology of our unrivalled county. It is only right that attention should be again drawn to our series of Permian Excursions, under the able leadership of Mr. B. HOLGATE; we have had three of these special excursions during the last session, and to use the words of an accomplished critic and geologist, "The Association has struck out a special line which must "be commended to geologists as a good example, viz., the organizing "of a series of excursions for the study of a particular subject; the "subject chosen is the rather neglected one of the Yorkshire "Permians." The excursion on the new railway from Beeston to

Batley, so ably conducted by Mr. ROWLEY, exhibited many good sections in the Middle Coal Measures which would otherwise have been unknown to the members. The same remarks upon the value of railway sections must also apply to the Market Weighton excursion under the Rev. E. M. COLE, when the new railway in construction to Bridlington revealed some splendid sections in the Middle Chalk.

To the conductors of the excursions, the authors of papers, and the exhibitors of lantern-slides and geological specimens, the COUNCIL tender their hearty and sincere thanks.

ATTENDANCE.

The attendance of members at meetings and excursions during the past session has been most encouraging, being on an average at the former 35, at the latter 20. There have been four Council Meetings, with an average attendance of six.

TRANSACTIONS.

The fourth part of our Transactions was issued in the spring, and its contents have been welcomed with encouraging approbation. Its value was further enhanced by the addition of a frontispiece in the shape of a portrait of our President. This, too, has been recognised as a marked improvement to our yearly publication.

OUR PROGRESS.

In addition to the increase in Membership, the value of our field Excursions, and the benefit of our evening Meetings, it should be stated that since our last Annual Meeting, our Association has been admitted as a Corresponding Society of the British Association. This really has given us a position as the premier scientific society in Leeds, it gives us a seat upon the General Committee, and entitles us to a copy of the "Transactions of the Association," which has been duly received and placed in our library; further, the titles of papers read before our Association are registered by the British Association and published in their Proceedings. In connection with the visit of the British Association to Leeds in 1890, it should be mentioned that Messrs. J. E. BEDFORD, F.G.S., B. HOLGATE, F.G.S., and WM. CHEETHAM have been selected, on behalf of our Association, to serve on the Local Committee, and our President has been appointed

one of the Secretaries of Section C (Geology) for the Leeds Meeting. The Secretary (Mr. S. A. ADAMSON, F.G.S.), represented the Association upon the General Committee of the British Association at the Bath Meeting.

GENERAL.

The appointment of an Assistant Secretary has been found very beneficial, and Mr. APPLEBY'S services have been very valuable. The COUNCIL, whilst thanking him heartily for his past services, regret that other engagements prevent his continuance of the office. The Treasurer has faithfully discharged the duties allotted to him at the commencement of the session, but it must be confessed these would be considerably lightened by greater promptitude in the payment of subscriptions. Members have again been found willing to help kindred societies in other towns by lectures, &c., and the COUNCIL record with pleasure the names of those who have thus endeavoured to spread a knowledge of geology, viz., Messrs. BEDFORD, CHEETHAM, HOLGATE, and ADAMSON.

MEETING ROOM.

The COUNCIL have pleasure in stating that, by the kindness of the Directors of the Leeds Mechanics' Institution, the old Science Lecture Room has been granted, on advantageous terms, for future meetings of the members. The room in question is admirably suited for our requirements, and attached to it is a Committee Room. By this change the comfort of members at our meetings will be materially increased, and the COUNCIL feel confident that this will further advance the progress of the Association.

PAPERS

READ BEFORE

THE LEEDS GEOLOGICAL ASSOCIATION.

JANUARY 17TH, 1889.

Mr. J. E. BEDFORD, the President, in the Chair.

"CEYLON'S ISLE"

BY Mr. JOHN INGLEBY.

(Abstract).

After speaking upon the history and meteorology of Ceylon, the lecturer described its physical geography. From the sea-board for several miles inland, the distance varying considerably, are large tracts of low lands and undulating plains; the portions easily irrigated are under cultivation, the higher portions are jungles or native gardens. Towards the centre of the island we reach the mountainous zone, which occupies about one-third of the island. Adam's Peak was up to a recent date considered the highest mountain; it can be seen far out at sea rising up like a sugar-loaf, whilst other mountains are further inland, and not so isolated or abrupt. The highest mountain is Pedro-tala-gala, which has an altitude of 8,260 feet. On the coast must be mentioned the lagoons, or lakes, which vary in size, some being quite small, others several miles in length. During the dry season the water is generally brackish, but after being flushed out by the torrents of the south-west monsoons they are quite fresh. Before the end of the rainy season, however, the mouth of the lagoon where it overflows into the sea gets silted up, and a sand-bar is quickly formed; the waves wash over this, but do not return, and in course of time the whole lagoon becomes brackish. This is a great misfortune, for adjoining the lagoon there are often, indeed generally, large tracts of land in every other respect admirably adapted for the cultivation of rice; but the salt effectually stops this. The scenery of the lagoons is beyond description; they are studded with islands; and trees and flowers, both terrestrial and aquatic, are to be seen in gorgeous profusion. There is the red lotus and white water lily, the flaming foliage and delicate flowers of the ironwood tree, the green of the palms blended together in such admirable confusion as to render an adequate idea of this rich picture impossible.

The Singhalese name for the island is "Lanka" (Holy Land). To the ancient Greeks and Romans it was known by the name of Taprobane; this is the Sanscrit name, and means the "wilderness of prayer," or the hallowed groves whither pious pilgrims repaired from the furthest corners of India to offer gifts and devotion to "the unknown God." Sir Emerson Tennent says the Galle, or Point de Galle, which up to a few years ago was the chief seaport, can boast of being the most venerable emporium of foreign commerce in the world, as probably it was the Tarshish of Solomon. Yet supposing that the Hebrew monarch did obtain "ivory, apes, peacocks, and gold" from Ceylon, we have no record that gold was ever discovered in any quantity, though many Singhalese names of places (such as Rang-welli, "Gold sand") might well lead us to suppose it has been; and at the present moment European capital is being expended in prospecting for gold. All the nations which profess the religion of Mahomet, to this day look upon Ceylon as the elysium ordained by Providence to console Adam and Eve for the loss of Eden; and by a strange coincidence the famous Arabi Pasha, who is an exile here, derives no small comfort, it is thought, from this tradition. Mr. Ingleby gave a graphic account of the vicissitudes of Ceylon under its various masters, beginning with the Aryan invasion in the fifth century B.C. The records of its history are not only found in legends and songs, but there are inscriptions on coins and monuments; some of the latter are fully two thousand years old, and are only second to those of Egypt in vastness of extent and architectural interest.

The monsoons, or rainy seasons, which divide the year into two portions, were next described. The north-east wind blows from November to March, from the cold mountain regions of Asia; the nights are cooler, but the days are hotter than when the south-west monsoon prevails. In March the heat increases until it becomes intolerable, rising to over 96 deg. in the shade. The sun is vertical; and all who can avoid exposure do so. Thunder now begins to be heard; at last the change, so ardently desired, arrives. Amidst violent gusts of wind the storm breaks, generally at evening or night. Thunder seems to shake the earth to its foundations, and the lightning flashes with a vividness unknown in this country. No one who has not lived in the tropics can conceive the violence of the elements at this time. Every room is illuminated to its remotest corner with a distinctness which makes the lamplight appear dim indeed. Whilst this is going on the rain comes on with such vehemence that you think another Deluge will take place. Going out in the morning, you are inclined to think that magic has been at work, everything is so

fresh and green; and in less than twenty-four hours the ground becomes covered with a luxuriant carpet of verdure. Then the rain comes on again; but settles down, as well-conducted rain should behave.

In the mountains of Ceylon only granite, or gneiss, is to be met with. In some places the rocks tower like a huge wall 2,000 feet high, and in the sunlight sparkle with a rich ruby glow; the surface on examination is found to be studded with garnets, beautiful to look at, but of no value, the crystals being too small. In Ceylon is found that peculiar substance known as laterite (literally brick stone, derived from the latin word—later, a brick), which the natives term cabook. This is a peculiar clayey deposit of the Tertiary age, and hardens greatly and permanently on exposure. Granite is used for the roads, but cabook is a good binding material, and is used instead of gravel, hence the redness of the roads and the dust, which finds its way into everything and everybody. The wells of drinking water are generally cut into this cabook, and most of the cuttings either on the railway or the road-side show fine sections of it. It is not difficult to cut through, and in the low country it is quite safe to make a perpendicular cutting to almost any depth. In appearance the sections present much the appearance of a brick wall, only there are no lines marking the courses, and here and there you are sure to see boulders of granite interspersed. In the low country freshly uncovered cabook is comparatively soft, not quite so much as ordinary clay, but much more gritty. In the up country it does not harden to a great extent, and is more slippery, soft, and moist in character; very clayey, is generally permeated by water springs, and altogether is, in this part, an immense difficulty in the construction of railways, roads, &c. A few feet below the surface of the cabook we should probably find huge slabs of granite, perhaps at an angle of 45 deg. Often these slabs of rock are not covered at all, or only by a few inches of vegetable mould. Many a planter has been deceived by purchasing land which has turned out to be full of thinly covered slab rock, for when the wild vegetation is cleared off the sun dries up the little surface soil there is, and the first monsoon rain washes this away. There are acres covered now with slab rock which a year or two ago were covered with very fair jungle. This is a serious question for a speculative planter; but for an engineer to find this slab rock under clayey cabook is a calamity. If a railway engineer meets with rock directly in his path he can drill a tunnel through, and the question is settled once and for all; but to cut his road round the side of a hill of this formation is often only a question as to whether the mass above the road will slide down and block

the road, or the road itself will slide down the face of the hill; both cases are of frequent occurrence. Mr. Ingleby also described the manner in which bricks are made from cabook. The surface of the cabook is first levelled, then with a small pick trenches about an inch wide and six inches deep are cut in lines about six inches apart; these lines are crossed at right angles by similar trenches, say 15in. apart. In this manner bricks are formed, about 15in. by 6in. by 6in. They are yet attached to the bed below, but are easily separated one at a time by thrusting a spade horizontally under each brick. After having been exposed to the sun and air for a short time, they become hard, and are fit for building purposes. They are a very good substitute for stone, rough, of course; but buildings are always plastered. The Singhalese are particularly clever at plaster. The lime is burnt from coral; this is mixed with sand, and if for fine work, eggs and sugar are added. Mr. Ingleby's remarks upon laterite or cabook were felt to be specially valuable, as more information is wanted upon the mode of its formation. Lyell mentions some red partings of laterite between sheets of basalt in Madeira. He says these bands vary in thickness from a few inches to two or three feet, and consist sometimes of layers of tuff, sometimes of ancient soils derived from decomposed lava, both of them burned to a brick-red colour and altered by the contact of melted matter which has flowed over them. Rutley designates laterite "as a red earthy rock, which occurs in beds lying between basalt and other lava flows, and results from their decomposition. It is strongly impregnated with sesquioxide of iron. From the varying nature of the rocks from which it is derived, laterite has naturally a very variable composition, and indeed there is as yet no precise definition of this rock." Plumbago or graphite is found in laterite. The mining for this is performed by natives, but their appliances are very crude. Still some of the well-to-do natives, who mine on a large scale, will adopt a different course, and will sink 200 or 300 feet with very different appliances. The Government do not allow mining operations without a license, still large quantities are obtained and the tax evaded. The exportation of plumbago, which for crucible making is perhaps the finest in the world, often amounts to upwards of 10,000 tons per annum.

Coral reefs surround the island more or less; generally they are some little distance from the shore, and they receive the full force of the waves, forming fine breakers in the distance. But it is not alone at sea where coral is found. Mr. Ingleby states that in navigating the Madu Junga, a large lagoon on which he spent several months, he often took a short cut through a small canal which the natives had cut in order to avoid the tortuous course of

the natural outlet, and the banks and bottom of this canal, below about a foot of surface soil, were coral. And very curious it seemed to be, sailing under the shade of palms and bread-fruit trees, to see the white walls and bottom of coral. Rich iron ore is very abundant in all parts of the island. It is red hæmatite of exceedingly good quality, yielding splendid iron in quantities varying from 30 to 70 per cent. There is no coal, however; hence there is no iron smelted on a commercial scale. The natives smelt small quantities for their own use, using charcoal for fuel, and a pair of sheepskins for bellows. Imported iron, however, is much cheaper wherever transit is not excessive, and there is less native smelting every year. Gold has been found in many of the rocks in the mountain regions, and also in the sands of the low country. Of other minerals there are manganese, talc, arsenic, &c., and no end of precious stones. The latter are generally obtained in the low country, at the foot of the hills, by digging pits or by washing the sand of the rivers during the dry season. The latter is the easiest method, as it is only necessary to wade into the stream with a large basket, get it full of gravel, and allow the stream to wash away the mud. It is then taken to the bank, and carefully searched for gems. The first method, by digging pits, if more laborious is generally the most profitable. The order of the alluvial deposits met with is, commencing at the top, first the fertile loam, then a slimy black clay, next a bituminous clay, containing very often organic remains, and lastly, the gravel in which the gems are found. That beautiful white clay, known as kaolin, which is the result of the decomposition of felspar, is very plentiful, but up to now the sole use it is put to is that of white-washing. Salt is obtained in a very simple manner from sea water, and chiefly on the east coast. Water is allowed to flow on to low lying lands, salt pans as they are called, and then left to evaporate. It is afterwards collected and sold without any further process. It is, from being a Government monopoly, a great source of revenue. There is a heavy tax upon it, and many people think it a great hardship. The poor natives live on curry, and as this cannot be made without salt, none can escape the tax. It is a hardship too, that the salt cannot be sold for agricultural purposes, or for the curing of fish, at a cheaper rate than for food.

Mr. Ingleby also gave a vivid account of the famous pearl fisheries of Ceylon. The principal pearl banks are situated near Aripo, on the north-west coast, and a more dreary place than Aripo between the fishing seasons could hardly be imagined. The pearl banks are inspected and reported upon by a Government official, who fixes the time and place of fishing. When the due time arrives, a great change comes over Aripo, as probably there

will be a hundred thousand people from all parts of Asia gathered together. The miserable, low, dirty huts are hidden from sight by numberless gaily-covered booths, ornamented, as natives only can, with palm leaves and white cloth. There are boarding houses and places of entertainment; the place is full of vagabonds of every description, snake charmers, jugglers, fakirs, &c. Besides the swarming myriads on shore, the sea is covered with hundreds of native craft of every description, whilst a strong detachment of military and police from Colombo and a man-of-war in the offing are there to maintain order. The coral bank at Aripo is some ten miles long by two broad, and about eight miles from the shore. The particular part to be fished is marked out by buoys under the direction of the official before named. And now for the work. It is night. A huge bonfire blazes near the flag-staff (where the signals are given), lighting up the booths and bazaars with a lurid glare. A few strokes on a gong give warning that the appointed time is near, and there is a dead silence. The boats are at their places, and, frail-looking as they appear, some three or four thousand persons are crowded into them. A small field-piece is fired, and amid discordant yells, away shoot the boats. The usual complement for a boat is a captain and crew of thirteen, with ten divers. The latter are principally Malabars from Cape Comorin, and some from the Persian Gulf. They all wear amulets and charms against the dreaded shark. When at daylight the boats are all in their appointed places, there is again a time of suspense, the signal to dive is looked for from the Government ship; five of the divers of each boat stand on the gunwale, each with a stone, a net, and ropes. The Union Jack is run up, and as it reaches the masthead hundreds of divers plunge into the sea. They remain about a minute under water, and will bring up perhaps, if fortunate, 150 fish, and will descend about 50 times in the day—thus, two millions of pearl oysters may be fished in a day. The oysters are brought on shore and each boatload divided into three heaps, of which the Government takes two, and the divers, who have incurred the greatest risks possible, the third. This tax of 66 per cent. certainly does not err on the side of leniency.

FEBRUARY 21st, 1889.

Mr. B. Holgate, F.G.S., Vice-President, in the Chair.

At the February Meeting of the Association, the ordinary course of the syllabus had to be departed from, owing to a sudden and severe bereavement in the family of the President (Mr. J. E.

Bedford, F.G.S.). Mr. WASHINGTON TEASDALE, F.R.A.S., however, most kindly offered to give an exhibition of scientific views and subjects with his lantern. These were not all purely geological, but some branched off into kindred sciences, rendering the exhibition more varied, and adding at the same time to its educational character. Mr. Teasdale brought down his well-known sciopticon, with which he has made some 2,000 exhibitions of a similar nature, and from his rich stores of lantern slides he selected the choicest. First were shown a number of slides illustrating the rich palæontological objects in the Paris Museum; the colossal Megatherium, the sabre-toothed Machairodus, the Deinotherium with its enormous tusks, the gigantic reptile known as Mosasaurus, and the well-known Ichthyosaurus (of which we have such a good specimen in the Leeds Museum) were successively thrown upon the screen. These gave a fair idea of the strange and fierce denizens of the forests and seas of bygone geological periods. By way of contrast in point of magnitude, but not less in geological importance, were exhibited some highly magnified specimens of those exceedingly minute but wonderfully beautiful organisms known as Foraminifera, which have played such an important part in the building up of the earth's crust, particularly the cretaceous and tertiary limestones. A set of slides illustrating those equally beautiful microscopic objects known as Diatoms was also shown. Next came a series of well-know pictures, the various rooms, with their included objects, of the Leeds Museum. These were remarkably clear and good, and Mr. Teasdale also introduced portraits of those two talented and persevering men who in past years have worked so unselfishly and unremittingly for the welfare of the Museum, and done so much in raising the various collections to their present high standard—the late Mr. Henry Denny and Mr. Eagle Clarke. The members had next displayed a series to illustrate the forms of water, which as snow and frost crystals, icebergs, glaciers, &c., are such potent influences in geological operations. Next were some views of the gigantic craters and extinct volcanoes of the moon, followed by a series to illustrate sections of wood and fossil teeth, algæ, parasites, &c. Some well remembered scenes of former enjoyable field excursions were reproduced, including the remarkable contortions of mountain limestone at Draughton, the celebrated Silurian erratics at Norber, the weathered grits of Plompton, the fine examples of denudation on the cliffs of drift at Filey, sections at Blubberhouses, &c. Mr. C. BROWNRIDGE, F.G.S., also brought a number of slides, including the renowned fossil tree of Clayton, the junction of the Millstone Grits and the Magnesian Limestone at Knaresborough, the Craven anticlinals at Hambleton, Haw

Bank, Skibeden, &c.; the sections in the Lower Coal Measures at Hunslet, Dolly Lane, and Newtown, in Leeds; sections on the Skipton and Ilkley Railway, &c.

MARCH 21ST, 1889.

Mr. J. E. BEDFORD, the President, in the Chair.

"THE PHYSICAL FEATURES OF INGLETON," BY Mr. C. D. HARDCASTLE.

The range of mountain scenery presented to the eye from the Storr's Common, elevated about 100 feet above Ingleton, and half a mile from it, is extensive, panoramic, and, for such an elevation (870 to 900 feet above the sea), almost unparalleled in Yorkshire. Fronting south-west is the towering head of lofty Ingleborough, 2,373 feet above sea level, with its succession of terraces, fells, and scars. Northwards, higher still (2,414 feet), overlooking Scales Moor, with Blea Moor on its east, may be seen the highest point of Whernside; and to the north-west, Twistleton Scars, Gragreth or Gragarth, Hunt's Cross, and beyond these Casterton and Middleton Fells, and yet further still, some of the Lake District mountains. To the south-west, along the Vale of Lune, by Warton Crag, the eye rests pleasingly on the gleaming waters of Morecambe Bay and the estuary of the Lune, near Lancaster. Turning southwards, across the undulating plains between Lunesdale and Ribblesdale, may be seen Longridge Fells, Burnmoor, and the knolls of Bowland.

The town of Ingleton is surrounded by, or nestles, as it were, at the feet of three lofty mountains. Northwards, slightly inclining towards the west, is Gragreth, its summit, 2,250ft. high, being 6½ miles away, and its south-western boss, Hunt's Cross, a mile and a half distant. Northwards, too, is the huge wedge-shaped mass of Whernside, with its summit (Gable Rake) 2,414ft. high, and six miles away; its southern spur is named Twistleton Scars. Almost directly east lies Ingleborough, the chief feature and boldest outline in the district (2,373ft. high), at a distance of about three miles.

THE WATERSHED.

The line of water parting between the watershed of this district, that of Dent Dale, and those of the sources of the Yore, the Ribble, and the Wharfe, may be drawn from Hunt's Cross (1,150ft.) along the ridge of Gragreth to its highest peaks, Green Hill and Crown Hill (2,050ft.), through High Peak on Foul Moss (1,760ft.), Whiteshaw Moss (1,560ft.), Windhaws (2,025ft.),

Whernside, Newby Head (1,300ft.), Blea Moor (1,753ft.), Wald Fell (1,829ft.), Dodd Fell (2,189ft.), Fell Close (1,835ft.), Southhouse Moor (2,050ft.), Simon Fell (2,087ft.), and Ingleborough. The drainage of the whole district converges towards the town, and is carried off by the river Greta westward to the Lune.

Structure of the Mountains.

Gragreth, Whernside, and Ingleborough, are all capped by Millstone Grit succeeded by the Yoredale Series of alternating shales, sandstones and limestones. These rest upon a dense mass of compact limestone, this again upon Silurian strata, here and there visible in the valleys and the water-courses. Taking Ingleborough as an example, the succession and thickness is Millstone Grit, 300 feet; Yoredale, 700 feet; Mountain Limestone, 1,350 feet, the latter projecting on every side in bold scars and terraces; at the base is the Silurian, which is seen in certain districts, and doubtless underlies the whole. This structure accounts for the peculiar phonomena observed all over the watershed, of innumerable springs and streams issuing and lost in "shake holes," "pans," "pot-holes," &c., forming underground currents, passing through caves and reappearing at the surface in considerably augmented volumes. When small streams springing in the grits and shales approach the Mountain Limestone they frequently percolate through what were originally cracks, joints, or fissures in the limestone, widened in time by chemical and mechanical action into what are now known as swallow-holes, pot-holes, &c.

Kingsdale Beck.

According to the nomenclature of the Ordnance Survey, the river Greta is formed by the junction at Ingleton of two streams, viz., the Twiss, Greet, or Kingsdale Beck (which flows between Thornton and Twistleton), and the Doe, or Dale Beck, from the hamlet of Chapel-le-Dale. The confluence occurs about 20 yards north of the viaduct on the London and North-Western Railway. Kingsdale Beck is formed by the union of numerous small streams, draining the western flanks of Whernside, the eastern of Gragreth, and the mosses and highlands between them south of Dent. Long Gell, the principal stream, drains White Shaw Moss. In its course to Kingsdale Beck it receives on its right bank several tributaries. From Kingsdale Head forward the name of Kingsdale Beck pertains, which, near Kingsdale House, is augmented by Backstone or Blakamaya Gill on the right, and Fiddler Gill and Buck Beck or Gaye Gill on the left bank. Having increased to a fair body of water, the beck disappears in a rift between Yordas Cave and Brown Hill, and flows in a sub-

terranean passage for a distance of over a mile and a half to Keld Head, a little above Raven Ray, receiving in its underground course a considerable affluent from Gragreth, which may be seen in different parts of its course at Routing Cave, Yordas Gill, and in the dark recesses of Yordas Cave, where it forms a lovely cascade in what is called the Chapter House. During the greater part of the year the open channel from Yordas to Keld Head is dry. This portion of the dale is broad and level, and appears at one time to have been filled in with the waters of a lake, which has been drained off by different channels, traces of which may still be seen. At Keld Head (Norse for Spring or Well Head), the Twiss, as we will now call it, issues in a considerable volume, from under a wall of compact limestone, immediately under the wall of the highway to Dent, and in a few hundred yards enters the chasm or canon of Raven Ray, where it cuts its way through limestone rocks, remnants of which, in large blocks, overhang on either side of the stream from 50 to 80 feet, rendering the passage cavernous and gloomy. Shortly afterwards the waters are precipitated over a ledge of limestone at Thornton Force, originally 90 feet, now 60 feet high, by several bounds, the last one being from 30 to 40 feet, into a pool scooped out of the Silurian slate on which the limestone rests. The beck pursues its way thence through limestone and Silurian rocks in deep channels and gullies. At Pecca the Craven Fault crosses and brings the Silurians into greater prominence. From below Pecca, at a second fault, the valley widens on the right bank, but on the left it is somewhat precipitous. On leaving the limestone spur of Meal Bank, the beck pursues its way through Broadwood, with thick beds of drift on either side, to join the Doe and form the Greta.

The Doe.

The eastern flanks of Whernside are drained by streams from innumerable springs which unite to form Littledale Beck, this after receiving small affluents from Blea Moor, &c., and on reaching Winterscales changes its name to Winterscales Beck; thence flowing south-westerly by Gummerfleet it enters "Shake-holes" by Ivescar-end Moss, and in its subterranean course passes through Gatekirk Cave, whence it issues, and after running a short distance, overshadowed by underwood, again hides itself from the light of day, and in its underground course receives (as proved by Mr. Metcalf and others), a little below Jingle Pot, Ellerbeck, which forms the waterfall in Weathercote Cave. In times of flood the subterranean passage is insufficient to carry away the superfluous water, which consequently rises and overflows Jingle Pot and Hurth Pot, and occasionally Weathercote.

It then flows down the dale in an open channel to God's Bridge, though this channel is usually dry. The place called God's Bridge is a limestone rock, over which these superfluous waters flow to meet the main stream, which emerges from a lower stratum of the limestone on the right bank of the channel, and close by its side another stream accompanies it (supposed to be the lost water of Mere Gill from Black Shiver Moss). From a few hundred yards below God's Bridge the Doe flows over Silurian strata to within half a mile of the town, forming several waterfalls at Beesley's, and passing through a deep gorge at Baxen Ghyll. At the Craven fault it enters a limestone channel, in which it continues to its junction with the Twiss.

The Jenkin Beck.

A little below the town the Greta is augmented by the Jenkin Beck, which rises on Ingleborough Scars (1,450ft.), and after sinking and reappearing several times, notably at Rantry Hole and Crina Bottom (a small farm-house in a valley or depression on the hill-side), flows through a ravine (called Ease Gill). On crossing the Craven Fault a pretty waterfall of 25ft. is formed. The stream then passes Yarlsber, and runs in a south-westerly direction to join the Greta, near Park Foot.

The Clapham Beck.

The south-western portion of Ingleborough is drained into the Wenning, which carries its water in a westerly direction from the neighbourhood of Clapham, through an undulating plain from 350ft. to 500ft. above sea-level, to the Lune, a little beyond Bentham. One of the principal tributaries of the Wenning, on the right bank, is Clapham Beck, which flows through Ingleborough Cave. It is formed by the union of several streams rising in the scars south of Ingleborough; and as Fell Beck flows into Gaping Ghyll Hole, whence it flows in a subterranean passage to Clapham or Ingleborough Cave; this passage may be considered as part of the cave, the roof of the portion at Gaping Gyhll Hole having fallen in and been washed away with the stream. Gaping Gyhll Hole, with its subterranean connections, is one of a series which serve to honeycomb the watershed in all directions—indeed, passing over the watershed on the flanks of the three mountains, they may be counted by scores or hundreds, varying in size, depth, and extent of their ramifications.

Caves, Swallow-Holes, &c.,

The most notable swallow-holes, pots, chasms, gorges, caves, and subterranean passages in the area under consideration are Long Kin Cave and Long Kin Holes East, nearly a mile

north-east of Gaping Ghyll Hole; these being three fissures connected by a subterranean passage through which a small stream flows, and which ultimately finds its way into the Wenning either by Crummock Dale or through the Ingleborough Cave. The southern fissure is 114ft. and the northern one 220ft. in depth.

Gaping Ghyll Hole is a perpendicular shaft in the limestone scars north-west of Clapham, about 350ft. deep, with an elliptical opening 21ft. by 10ft. The waters of Fell Beck, collected during a course of two miles on the side of Ingleborough, fall into it, and are conveyed, as previously stated, to the Clapham or Ingleborough Cave, whence they flow as Clapham Beck.

Clapham or Ingleborough Cave is a long, narrow, circuitous underground passage, which has been explored to the extent of 702 yards. It is crossed by several deep and wide fissures, forming chambers or expanded areas of considerable height, to which specific names have been given. They are lined with stalactitic coatings of carbonate of lime, and adorned with fine stalactites suspended from the roof, and stalagmites on the floor of the cave, assuming peculiar shapes, from which their names have been derived. The entrance is at the foot of a precipitous limestone cliff from 60ft. to 70ft. high, and forms an arch 56ft. wide and 15ft. high, which gradually grows narrower for about 12 yards. Here an iron grating and gate are fixed, the key to the latter being held by the guide. The first portion, called the "Old Cave," is about 70 yards long, 18 yards wide, and 3 yards in height. The second chamber, called the "Vestibule," or "Eldon Hall," from the fact that Lord Eldon was with Mr. Farrer, the proprietor, when the opening was first made, is spacious and lofty, as the result of a cross fissure. The third chamber, the "Pillar Hall," is 140 yards from the gate, and contains the "Jockey Cap," "Belfry," &c. The fourth large chamber, the "First Gothic Arch," is 260 yards from the entrance. Beyond this are long, narrow, and low galleries, in two places between 4ft. and 5ft. in height. Several fissures, forming what are termed "arches," are passed, until the "Second Gothic Arch" and "Giants' Hall" are approached. Here is the principal fissure, reaching upwards some 60ft. or 70ft.

Long Kin Cave or Hole, west, or L Hole, on the western flank of Ingleborough, is nearly 300ft. deep, and shaped at the opening like the letter L.

"Tatham Wife's" Shake Hole, is 100 yards in circumference and 17 yards deep, measured obliquely.

Barefoot, or (according to the Ordnance Survey) "Braithwaite Wife's" Hole, another shake-hole, is 55 yards in diameter and 25 yards deep.

Mere Gill Hole is a deep, narrow ravine or fissure, through which runs a moderately strong stream ; rising at a height of 2,000 feet, near the Swine's Tail, a spur of Ingleborough. This fissure is so narrow that in some places it can be easily jumped across, and reaches a depth of 100 feet or more. There are several waterfalls and a deep pool formed in the chasm.

In Kingsdale, on the east side of Gragreth, may be mentioned Rowting or Rowantree Cave, Jingling Cave, Yordas Cave, Bull Pot, and Swinste Hole—through all of which streams flow which unite underground in the passage to Keld Head.

The Yordas Cave.

Two small streams, each called Yordas Gill, flowing through the Turbary pastures, unite at Yordas Grains and enter a rift at Yordas Wood, after forming two or three low waterfalls. The united stream reappears in the Chapter House, as it is called, forming a lovely cascade, and flowing through the greater part of the cave. The entrance to the cave is in a wooded glen, west of the Kingsdale highway to Dent, and at the foot of a precipitous rock. The mouth of the cave (8 feet wide by 7 feet high) is below the level of the road, and is reached by a rough flight of steps. A few yards from the entrance the rock lowers to about 5 feet, but immediately opens out into a lofty chamber about 60 yards long by 16 yards broad, and varying from 12 to 24 yards in height. The lower portion of the floor is covered with a soft mud, left by the annual overflows in the winter season of the stream already alluded to, which has left evidence on the walls of having recently filled the cave to a height of 5 feet. The higher parts of the cave near the bank are covered with stalagmite. Some fine stalactites adorn the roof and coat the walls of the cave. One, representing a bishop's throne, with seat and canopy supported by wreathed and fluted columns, is a splendid specimen. The Chapter House is a beautiful circular apartment at the extremity of the cave, about 6 yards in diameter and 12 yards in height, terminating in a pointed dome covered with delicate stalactites, and supported by slender, twisted columns. The cascade in the Chapter House has a fall of 55 feet, but in an oblique direction.

Several attempts have been made to open out caves on the Storr's Common, but difficulties have arisen. There are no signs of human or other habitation of the caves of this district. The western limit of the cave population, either men or animals, appears to have been about the neighbourhood of Settle.

Glacial Drift and Erratics.

The surface covering underneath and about the town of Ingleton, south of the Craven Fault, is a local glacial (perhaps morainic) drift, composed chiefly of sand, gravel, pebbles, and boulders, with a not very large admixture of clay. The boulders, especially those of limestone and calliard (uncleared slate or Silurian grit), vary in size from five or six inches to two or three feet. The depth of the drift varies from 60 or 70 feet under the town to from 100 to 150 feet in the Broadwood and Enter Banks deposits, to the west of the Twiss and the Greta. At Lundholme, south of the town, are extensive terraces of drift, which are evidently connected with the line of drift at Broadwood and Enter Banks, and of a somewhat similar nature, except that the boulders are smaller. They consist, as does most, if not all, of the drift under the town, of materials from the watershed under consideration, those of Mountain Limestone predominating. Next perhaps in order varieties of Silurian and Millstone Grit, Yoredale limestone and sandstone, these latter being generally and comparatively smaller, having by their softer nature been ground up, and thus compose the sandy, &c., portion of the drift. Overlying the drift, and sometimes lying exposed on the bare limestone, but especially in the bed and on the banks of the Doe and the Greta, for a distance of two miles or more down the stream, are large blocks of stone of the Borrowdale Series of Professor Harkness and the Ordnance Survey, or Green Slates and Porphyries of Sedgwick. Some of these are porphyritic in character, and are all doubtless derived from a band of the series which stretches across the valley of the Doe from beneath the Twistleton Scars on the west to the Raven Scars on the flanks of Ingleborough, and about 400 yards in width from north to south, and about two miles to the west of Ingleton. The largest erratic the author has observed lies in a field belonging to Skirwith Farm, and on the eastern side of the highway. It measures 10ft. in length; top diameters, 7ft. 6in. and 6ft.; height 4ft. above ground, and apparently resting on it, though some portion of it may be buried; height above sea level, the same as the rocks *in situ* two miles beyond.

On Storr's Common, in the Bull Copy adjoining, and on the highway side are several blocks of more than a yard in length, and proportionately wide and high. Most of them are or have been irregularly rectangular. One of them, on the roadside below the gate leading to the Skirwith Limestone Quarries, measures about 6ft. by 4½ft. and 4ft. high. The southern part of the block is of a porphyritic character, containing numerous red felspar crystals, and the northern part of a fine-grained trap-like

character. Intermediately between the two extremes the texture is also intermediate.

Large blocks of a similar character are met with *in situ* in the quarries of the so-called Ingleton Granite Company, in the band just alluded to. The author showed six specimens chipped from one block, as it lay undisturbed from its original position. They varied in structure and texture in each instance, one large piece showing coarse and fine texture in close contact; some fragments contain red felspar crystals, whilst the rest are devoid of them.

The Craven Fault, &c.

The great Craven Fault, or system of faults, passes the town to the north-east, and runs in a north-easterly direction by Newby, Clapham, Settle, Malham, &c., branching off in different directions as it proceeds eastwards. At Ingleton, the faulted district is about half a mile broad, and consists of two or three distinct lines of fault, probably of different ages. Professor McKenny Hughes says "there are several faults parallel to one another, and one at least of pre-carboniferous age. Also it appears that sometimes one and sometimes the other has the greater downthrow; where the downthrow of one decreases that of the other increases, so that the total resultant downthrow is preserved." The most northerly line enters the district by the depression north of Hunt's Cross, crosses the Twiss by Pecca Falls south of Thornton Force, behind Twistleton manor house, to the south of the slate quarries nearest the town, through the enclosure called Bull Copy at Skirwith Farm, and across the Storrs to Ease Gill above the waterfall. This fault, called the Twistleton Fault, is supposed to represent a drop of about 300 feet.

From 80 to 100 yards south of this another fault or line of fracture appears, in which two or three dikes of mica trap occur, and about 60 yards further south still what is known as the Tow Scar Fault comes from the direction of Tow Scar, a south-western boss of Gragreth, along the southern escarpment of Hunt's Cross, across the Twiss below Pecca, and the Doe at or near the Cat-leap waterfall, bringing up the Mountain Limestone against the shales overlying the Coniston Limestone. Two of these lines of fault appear to converge and meet in or just beyond the valley of the Doe. Indications of converging surface lines may be traced on looking from the Storrs towards Hunt's Cross, but only one line can be seen at Skirwith and further east. The most southerly line recognised by the Ordnance Survey enters the district near Thornton Hall, and on that account is called the Thornton Hall Fault. It crosses Broadwood north of the Weir, by the southern portion of Meal Bank near the limekilns, across the Doe at or

near the Weir, behind the Ingleborough Hotel and Blue Hall, past the Court-house and by Yarlsber and Slatinber to Newby, when it bifurcates, one portion running to the north and the other to the south of Clapham. Mr. Balderston thinks he has found indications of another fault, which he calls the Hollin Tree Fault, because it passes Hollin Tree House, a little below the Midland Railway Station. The whole district is covered with drift, and the faults are difficult to trace, but he thinks that a sudden dip of the beds, observable in the bed of the Greta, indicates the presence of a fault, passing from Westhouse towards Greenwood Leghe.

The Pennine Faults, &c.

By some authorities the Craven system of faults is considered to be directly connected with the Pennine system; to be, in fact, a branch from the southern extremity, as the Tynedale (which in different parts of its course is named the Stublick, the Great Bur-Tree Ford, and the Ninety-fathom Dike) is supposed to be near the northern extremity; whilst other authorities treat each line in one direction as a distinct and independent fault. The author showed a diagram which represented the whole series. What is usually denominated the Pennine Fault was shown by a line running in a N.N.W. and S.S.E. direction from Penton Linns in Dumfriesshire, by Brampton, to Brough. The line from Brough, by Dent, to Kirkby Lonsdale, is called the "Barbon" Fault by Prof. Hughes, and the Craven and Tynedale Faults are said to be independent lines striking the direction of the Pennine Fault at somewhat similar angles, but having a displacement of a totally different nature. Prof. Sedgwick makes the Pennine Fault end and the Craven Fault begin at Brough. Prof. Phillips continues the Pennine Fault to Kirkby Lonsdale, and commences the Craven Fault at that place; while Profs. Harkness and Nicholson treat each line as a distinct fault, one bearing upon another at considerable angles, and probably produced at somewhat different times, though perhaps in the same geological period. Numerous other large faults occur in almost direct parallelism to the Pennine series, and probably have exercised a considerable influence on the configuration of the country, as most of the principal valleys coincide with lines of fault.

Effects of the Craven Fault.

Although the Millstone Grit caps the summit of Ingleborough, as already stated, yet on the south side of the fault, in the valley, the same rock is overlaid by a representative of the Permian series, and a section of the Coal Measures, making, according to the best authorities, a total dislocation of about 3,200 feet. The

Permians are represented by a red, sandy, pebbly conglomerate, called "Brockram," and the Coal Measures are supposed to be the equivalent of the Burnley coalfield. It has been observed by Professor Phillips as remarkable that at the northern extremity, or nearly so, of the Pennine range, as at the southern, similar coalfields occur, as, for example, the Hartley Burn coalfield, south of the Tynedale Fault, and the Ingleton coalfield, south of the Craven Fault; and it has been suggested that the Northumberland, Yorkshire, and Lancashire coalfields may have once been united, and that the measures of the intermediate area may have been broken up, denuded, and carried away.

The Silurians of the Twiss and Doe Valleys.

These are generally recognised as a portion or the equivalent of the Green Slates and Porphyries of Sedgwick, or the Borrowdale Series of Harkness and the Ordnance Survey. The whole series may be examined whilst walking up the valley of the Doe from Cat-leap Falls at the entrance to Beezley Glen, to a few hundred yards below God's Bridge. The series, a descending one, commences with contorted shales, supposed to be the equivalent of the Ashgill Shales of the Lake District; then Coniston Limestone, feebly represented here, the trap-dykes passing probably between the shales and the limestone, and these succeeded by a hard brown felsitic ash band. The author showed various specimens of the rocks just named. A band of fine cleaved slates occurs next, which has been worked on both sides of the river for roofing purposes. Beyond the slate quarries appear uncleaved calliards and grits, with intercalated beds of what is usually termed trap, although probably not a true lava. Near Beezley Farm a coarser band of slates occurs than the one lower down the stream, which has also been worked. From thence to Dale Barn no section is visible. Here we arrive at the so-called porphryitic band alluded to as yielding the boulders distributed over the district to the south, which is now being worked by the Ingleton Granite Company, and offered for sale as crushed and broken granite for macadamising purposes. Beyond this again are roughly cleaved green slates, grits, and felspathic ash-beds, which disappear, as already stated, a little below God's Bridge, under the conglomerate and Mountain Limestone. Professor Hughes says, "If we have here an unbroken ascending series, there must be more than 10,000 feet of green slates seen in this valley;" but suggests that though none of the beds appear to be repeated, there may be a hidden fault or fold which may affect the measured distance. Professor Nicholson agrees with him. Mr. Balderston says there

is a fold or anticlinal, which causes the beds of the lower part of the valley to reappear in the upper part.

The Conglomerate.

A bed of conglomerate of variable thickness lies unconformably on the Silurian beds, and forms the basement bed of the Mountain or Great Scar Limestone. There are not many clear sections to be seen; the best are at Thornton Force, Skirwith Quarry, and in the bed of a small tributary to the Doe, between Dale House and the Twistleton Scars. This section being the most remarkable, as containing bands not seen in the others, may be given in detail. A bed about two feet thick of iron-stained coarse conglomerate, consisting of rounded Silurian and quartz pebbles, lies unconformably on roughly cleaved slates; on this about a foot of clayey shale, and above this about three feet of limestone or calcareous shale, consisting of thin bands of shale at the bottom, and becoming more solid in the centre, and of a shaly nature again at the top. Perhaps the upper and lower portions have become more shaly on account of decomposition.

A bed of coralline limestone from four to six inches thick rests on the bed of calcareous shale. In the immediate neighbourhood there is a bed of Lithostrotion Basaltiformis. Above the coralline limestone lies a coarse conglomerate, growing finer as it proceeds upwards for about two or three feet. Bands of conglomerate and bands of limestone alternate, the conglomerate becoming finer until the solid limestone occurs and continues, still coloured with Silurian mud.

Origin of Valleys.

The valleys of the Lune, Rawthey, Dee, Wenning, and others in the district coincide with lines of fault, as do also many of the deeper depressions of the Lake District. The valleys of the Doe and Twiss, as we have seen, are crossed by lines of fault. It is thus generally inferred that the origin in the first instance of most of these valleys, and consequently the configuration of the country, is due to the influence of lines of fault and subsequent removal by denudation of the disturbed and broken material. The valleys once formed would be deepened by the mechanical and chemical action of water, and afterwards scooped out and widened by glacial action. The present features as to escarpments, &c., being probably due to subsequent sub-aerial denudation.

The lecture was fully illustrated by maps and diagrams, and also by a large number of specimens which the author had personally obtained from the sections described.

APRIL 18TH, 1889.

Professor MIALL, F.L.S., &c., in the Chair.

"THE APPLICATION OF THE LAWS OF COMPARATIVE "OSTEOLOGY TO THE PALÆONTOLGY OF THE "VERTEBRATA."

BY Mr. ARTHUR SMITH WOODWARD, F.G.S., F.Z.S., of the British Museum (Natural History).

(*Abstract*).

Precision in the results of Palæontological research depends almost entirely upon the extent to which the hard parts of an organism afford a clue to the arrangement of its soft tissues. The stony framework of corals, the shells of mollusea and echinodermata, and the hard armour of crustacea, bear characteristic marks of the vital organs they are destined to support; and in most instances these skeletons are capable of philosophical treatment, even when found as imperfectly preserved fossils.

In the case of an animal with bones, however, much more insight can be obtained into its structure from mere fragmentary skeletal remains. The basis of bony tissue is a fundamental part of the organism from its earliest stages; blood circulates through it just as through any other part of the body; and most of the muscles, besides many of the blood-vessels and nerves, leave distinct impressions upon the parts of the skeleton over which they pass, and by which they are supported or protected. Every crest, ridge, tuberosity, hollow, and perforation is thus of significance in the interpretation of a bone; and there is a remarkable constancy in the combination of characters displayed by the skeletons of each of the five great classes of existing vertebrated animals. Every class seems to exhibit all the minor features of its skeleton arranged upon a plan peculiar to itself, and distinct from that observed in each of the other classes.

Baron Georges Cuvier, at the beginning of the present century, was foremost among those who recognised not only this fact, but also the curious interdependence between one part of the skeleton and all other parts; he, indeed, the author of the "Ossemens Fossiles," must be regarded as the founder of the Science of Comparative Osteology. Moreover, it is interesting to observe that Cuvier was especially urged to pursue his investigations by the study of fossil bones. The occurrence of large bones in the river deposits of the Continent had long been known, and some naturalists had ascribed them to human giants, while others rightly recognised their true reference to elephants, though

usually supposing them to be the remains of animals introduced by Hasdrubal and the Romans. Cuvier discovered, by careful comparison, that the fossils indicated an unknown species of elephant, distinct from each of the two forms met with in Africa and India; and the fact was one of such interest as to induce the French anatomist to devote the remainder of his life—fortunately a period of thirty-five years—to the study and elucidation of all the fossil bones he could find. As the result of his researches, Cuvier arrived at the conclusion that "a claw, a shoulder blade, a condyle, a leg or arm bone, or any other bone separately considered, enables us to discover the description of teeth to which they have belonged; so also reciprocally we may determine the form of the other bones from the teeth. Thus, commencing our investigation by a careful survey of any one bone by itself, a person who is sufficiently master of the laws of organic structure, may, as it were, reconstruct the whole animal to which that bone had belonged." With implicit confidence in this principle of "the correlation of structures," the pioneer in Vertebrate Palæontology not only assorted and correctly determined the numerous bones met with in the Eocene Paris Gypsum, but also made known the affinities of a large number of fossils from various parts of the world. His restoration of *Palæotherium*, from the Paris Gypsum, has proved especially accurate, a nearly complete skeleton, now in the Paris Museum, having been discovered a few years ago.

Cuvier had many distinguished pupils, and most distinguished of all, perhaps, is our own Professor Sir Richard Owen. He has spent more than fifty years in applying and extending the principles of his great teacher, and his first remarkable success was the discovery of the huge extinct wingless birds of New Zealand (*Dinornis*). Before any of the Maori traditions of these birds had reached England, Professor Owen had satisfied himself that such creatures must once have existed, merely from the examination of a single fragmentary thigh bone. Many other determinations of broken bones and detached teeth by the same naturalist have also proved well founded, and it might be thought, at first sight, that one with so keen a judgment could scarcely make a mistake. Sir Richard Owen's latest restoration, however—that of the so-called great horned lizard of Australia (*Megalania*)—is generally admitted to be an unfortunate failure; the backbone belongs to a lizard (*Megalania*), the head and tail are really parts of a turtle (*Meiolania*), and the toes are those of a pouched quadruped (*Diprotodon* or *Nototherium*).

Such a failure suggests the possibility of some error or inconstancy in the principles taught by Cuvier, and the more the

modern discoveries of natural history are studied, the more evident does it become that the bones of extinct animals cannot always be correctly interpreted merely by reference to those of creatures existing at the present day. The bones of the extinct flying reptiles (*Pterodactyles*), for example, are hollow, and many of them very like those of birds; so that before the complete animals were known they were often actually referred to birds. The well known three-toed footprints in the Trias of the Connecticut Valley, U.S.A., were also for a long time supposed to have been made by birds; but it is now known that they are really the tracts of extinct reptiles, which walked on their hind legs. The first remains of the great *Iguanodon* discovered in Kent gave no real idea of the character of the creature. Some of the bones of the hind-quarters were assigned to the shoulder, and the tip of the thumb was placed, in restorations, as an ornamental horn on the nose. Subsequent discoveries in the same beds led to the correction of some of the errors; but the complete skeletons of *Iguanodon*, met with some years ago in Belgium, were the first to give a true idea of the form and proportions of the animal. Many mistakes were also made before it was recognised that huge land-reptiles once existed, in which it was requisite for comfortable locomotion that some of the bones should be hollow and made light by hot air, like those of birds. Such monsters are the Atlantosauridæ from the Jurassic of Colorado, also represented by *Ornithopsis* in the Wealden of the Isle of Wight. Parts of the great wombat-like Marsupial *Diprotodon*, from Australia, were originally described as the remains of a kind of elephant; and it was naturally thought very remarkable that elephants should have once existed in that remote continent. When the front of the lower jaw of *Dinotherium* was first discovered in the Miocene of Eppelsheim, its singular tusks were turned upwards in the published restoration—an arrangement that naturally led to the enquiry as to how it would be able to feed. The so-called "pouched lion" (*Thylacoleo*), from the Pleistocene of Australia, is still under discussion; although the jaws and dentition are known in their entirety, it is still considered impossible to decide whether it was carnivorous or herbivorous in habit.

Many other difficulties still await solution; and one who merely watches the progress of research might well suppose that our knowledge of extinct vertebrate animals is of a very precarious kind, and not an item upon which much reliance or value can be placed. So many complete fossil skeletons, however, are now known from all parts of the world, that the science of fossil bones is gradually becoming far from guesswork and imagination. Indeed, these discoveries at last explain the meaning of all the

earlier difficulties. The older naturalists looked upon nature from too narrow a point of view; they knew nothing of the great principle of evolution, and hence they entirely misunderstood the world of life, and especially misinterpreted extinct animals. Supposed laws founded upon a study of the skeletons of horses and cows, or lions and elephants, are not capable of any wide application, because it is only yesterday, so to speak, that such creatures came into existence. Many of the Vertebrata of the present day can be traced back almost to common ancestors, which do not exhibit precisely the characters of any of their descendants, but combine in their structure the fundamental peculiarities of all of them. The extinct odd-toed hoofed animals culminating in the modern horse, for example, could not be interpreted merely by reference to the surviving members of the group; and the discovery of tolerably complete skeletons has alone rendered possible the recognition of the well known genealogy now widely accepted. No one, indeed, can determine from a totally unknown bone or tooth the exact characters and systematic position of the animal to which that bone or tooth originally belonged.

On the other hand, it is satisfactory to note that a few recently established principles are capable of general application; and the progress of research will doubtless soon lead to the discovery of more. To cite two examples, the shortening of the tail in an animal is a sign of extreme "specialization," and the absence of teeth—as in birds and monotremes—is a feature of similar character. A naturalist of the modern school would never restore the Triassic *Cheirotherium* on the basis of the tailless frog; because the specialization of the Amphibia in early Mesozoic times had certainly not proceeded so far as to result in types that had lost their caudal appendage. Moreover, the oft-expressed astonishment that the jaws of the earliest known Mammalia are suggestive of marsupials rather than of the more lowly monotremes, is founded upon a complete misconception at last revealed. The surviving monotremes, *Ornithorhynchus* and *Echidna*, are merely toothless on account of specialization; the absence of teeth is not an essential peculiarity of the lowly type to which they belong. True teeth, for a time in use, have lately been found in very young individuals of *Ornithorhynchus*; and these exhibit so much resemblance to those that evidently persisted throughout life in early Mesozoic forms like *Microlestes* and *Tritylodon*, that there cannot be much doubt as to the intimate relationship of the genera compared.

Comparative Osteology as known to Cuvier, and the latest phase of the Science resulting from Palæontogical discoveries,

thus exhibit a striking contrast. That there are certain definite laws and principles may be assumed without hesitation; but these are far grander than could be divined from a mere study of existing animals, and much progress must be made in research before they can be clearly formulated.

MAY 16TH, 1889.

Mr. J. E. BEDFORD, F.G.S., the President, in the Chair.

"ONE OF NATURE'S GEMS,"

BY Mr. W. H. FITTON.

(*Abstract*).

In commencing, the lecturer announced that his remarks would be on that chief treasure of the earth—Coal; and in discussing the question "What is coal?" referred to the controversy which raged some years ago upon the Torbane Hill coal. This was the subject of costly litigation, in which the evidence was most conflicting. Thus Ansted gave it no name, Brande said it was "a new, peculiar mineral," Chapman "did not hesitate to say it was a bituminous shale," Anderson said "it was not a bituminous shale, whatever it was," Hugh Miller said "it was the most inflammable shale he had ever seen," Milne and Wilson called it "clay impregnated with bituminous matter," Graham, Fleming, Hoffman, and other eminent men, said "it was unquestionably coal," and the case terminated without coming to a fair and clear understanding as to what is and what is not coal. Galletly defines coal to include "any solid mineral substance infusible under its point of ignition, and containing sufficient carbon to allow of its continuous combustion in the fireplace of an ordinary grate." The lecturer next defined what coal is, saying it is a mixture of hydrogen, oxygen, nitrogen, and carbon in variable quantities, with impurities, and that it is composed of plant remains, which have perished at or very near the place where they grew, and which have been covered up and compressed, and by means of chemical action have passed through various intermediate stages until they have arrived at their present state. This chemical action was very minutely detailed, and the analyses of wood, humus, peat, lignite, brown, household, and steam coals, ending with anthracite, were given.

Next was pourtrayed the appearance of this country during the Carboniferous period, the lecturer saying that probably the nearest existing parallel may be in the great swampy marshes in

the deltas of the Ganges and Brahmapootra, known as the Sunderbunds and the Jheels. Evidence of the changes caused by the decomposition of vegetation may be studied in the peat bogs of Ireland, where at the surface you can distinctly see vegetable structure; further down this gradually becomes indistinct, and the mass becomes darker and rather more solid, until it has the appearance more or less of coal. Professor Huxley, after studying the Low Moor Better Bed, is inclined to think that it is largely made up of spore cases of vegetation allied to our present club mosses. These spores are very light, and are highly inflammable. As to the temperature of the time when our coal was formed, Daubeny was quoted, who says that it was about 62·5 Cent. He arrived at this result by taking the means of the extremes of heat and cold for the different families of plants, &c., that flourished in that period. The problem as to the duration of the coal period was briefly alluded to. Phillips assumes that one inch of carbonaceous matter is formed in 127⅛ years; other estimates, however, vary.

Mr. Fitton divided this mineralised vegetable matter into peat, lignite, common coal, cannel, and anthracite. Peat arises from the decay of plants which have been the denizens of marshy ground, swamps, &c., and usually contains from 70 to 80 per cent of water. An analysis of seven Irish peats gives—Carbon, 58·18; hydrogen, 5·96; oxygen, 31·21; nitrogen, 1·23; ash, 3·43; specific gravity, ·528. Lignite is wood coal, or fossil wood, converted more or less into coal; it is dull, dark brown in colour, burns with much smoke and dull flame, gives less heat and is altogether poorer than house coal. It contains—Carbon, 67·4; hydrogen, 5·5; and oxygen and nitrogen, 27·1. Lignite is termed brown coal so soon as it loses, to outward appearance, its woody structure. The familiar common coal was next described. Cannel was probably formed in fresh-water lakes from vegetation that was carried down, became water-logged, sank, and was then covered up by other deposits. It contains fine specimens of fish remains, beautifully preserved. It is very compact and jet-like, breaks with a conchoidal fracture, and in splinters will burn like a candle, hence its name; an average cannel consists of—Carbon, 84·7; hydrogen, 6·4; oxygen and nitrogen, 8·9. Anthracite in burning develops great heat, and gives off no smoke, with very little flame; it is richer in carbon than any of the preceding; thus the mean of 10 common coals gave carbon 83·1; hydrogen, 5·3; oxygen and nitrogen, 11·2. Anthracite, however, was carbon 95·2; hydrogen, 2·5; oxygen and nitrogen, 2·2. It has been supposed by many geologists that the change from ordinary coal to anthracite and probably to graphite has been caused by heat. It has been observed that where an

igneous dyke runs against a seam of coal it often turns the coal into cinder, or a sooty mass, at the point of contact, but further away converts it into anthracite.

For the shipping trade an item of very great importance is that of specific gravity. The following gives roughly an idea as to the relative weight of British coals :—Welsh, average 82lbs. to a cubit foot; Newcastle, 78; Derbyshire, Lancashire, and Yorkshire, 79; Scotch, 78; Irish anthracite, 99. As the lecturer said, the uses of coal are manifold; it warms our houses, softens our metals, evaporates our salt brine, assists in our chemical works, works our steam engines, gives us light—in fact to recount its value fully would be a work of magnitude. Its consumption is estimated as follows upon the annual output. Mining and metallurgical industries use 12-40, and manufactures and locomotion 11-40, domestic (including gas) 13-40, export 4-40. The valuable products of coal were then touched upon, including gas, tar with its beautiful dyes, coke, &c., details concerning the latter being given. Next came a *résumé* of the history of coal, with an account of its use by ancient nations and their knowledge of the same. This part attracted much attention, particularly as the lecturer sketched the rise and progress of the coal industry in our own country. The contrast between the year 1259, when Henry III. granted a royal charter to freemen to dig coal at Newcastle, and that of the busy year 1888, when the output was given at 180 millions of tons, was well described.

The next paragraph was devoted to a very grave question, one of incalculable importance to future generations—the eventual exhaustion of coal so far as this country is concerned. If, as one authority points out, the output advances at the rate of 40 per cent. each decade, as it has hitherto done, then we are rapidly exhausting our chief means of national wealth and power. The output mentioned above would, at this increased ratio, reach in 1936 to more than a thousand millions of tons annually. The lecturer gave some forcible statistics to show the rate we are using up our coal, and quoted Jevons, who says, " we are drawing more and more upon a capital which yields no annual interest; but once turned into light, heat, and force is gone for ever into space." The only way to delay the inevitable evil day is to economise its consumption, to develop appliances, to utilise every unit of heat the coal contains, and to avoid the waste of " getting " at the collieries. Might not something be said as to the lavish manner we are shipping our treasures to other countries, regardless, it would seem, of our own future as a nation ?

Various samples of coal, economic products, &c., were

exhibited by the lecturer in illustration of his paper. A discussion followed, in which Messrs. B. Holgate, F.G.S., W. Lower Carter, F.G.S., R. Nunns, and other members took part.

OCTOBER 14TH, 1889.

Mr. J. E. BEDFORD, the President, in the Chair.

The sixteenth session of the Association was commenced with a social meeting of the members. In addition to the opening address of the President (Mr. J. E. Bedford, F.G.S.) there was an exhibition of lantern slides by Mr. Godfrey Bingley, and also an exhibition of fossils, minerals, precious stones, etc., by the members.

THE SPECIMENS

were typical and instructive in the highest degree. The President exhibited a fine collection of granites, mica schist, schorl, hornblende, gneiss, ores of tin, copper, lead, &c.; a collection of rocks from Jersey, including granite, syenite, apatite, diorite, dolerite, basalt, mica trap, rhyolite, indurated shale, &c.; rocks from Langness Point, Isle of Man, showing the Old Red conglomerate, trap, &c.; and two specimens of glass undergoing devitrification, spherulites could be seen forming in the one, and microliths in the other. These were splendid examples, and as the subject has been twice brought before the Association by Professor Green, F.R.S., in its connection with glassy lavas, they attracted much attention. The President's brother, Mr. H. D. Bedford, who has travelled much in New Guinea, sent a collection of stone implements and weapons of war used in that distant island, and this brought the members in contact with a state of things which once existed on our own island—the Stone Age. Another of the President's brothers, Mr. C. S. Bedford, exhibited a collection of rocks he had recently made in Norway. Mr. Godfrey Bingley had a fine collection on exhibition, comprising clay slates from Wales; Wenlock limestone, with its fine arabesque surface of exposed fossils from weathering; ammonites from the Lias, Magnesian limestone, schorl, barytes, fluor spar, septaria from the Coal Measures, specimens of coal and Carboniferous fossils, trilobites and encrinites from the Mountain Limestone of Malham, &c.

Mr. W. Cheetham brought specimens from his choice collection, including a piece of Yoredale sandstone, showing most remarkably the effect of weathering, and looking like a miniature Brimham or Plompton; a block of sandstone from Eccleshill,

which had been "slicken-sided" horizontally; some galena and its matrix from the same quarry, and also two remarkable pebbles, which that gentleman had obtained from boulder clay at an elevation of about 400ft. at Laisterdyke. They are of hard, compact sandstone, and, when broken, disclosed a striking history, one being found to contain a fine example of a portion of a Calamite, the other having the splendid impress of one of those beautiful ferns of the Coal period, known as Neuropteris. One pebble is flat, and half an ellipse in form; the other also flat and roughly square. Both are highly smoothed and also striated, the striæ being in different directions. Thus, these pebbles have distinctly inscribed upon them by Nature's graphic hand two epochs, separated from each other by an immense period of time, and exactly opposite to each other in character. The fossils being of the Carboniferous period, the smoothing and striæ of the Glacial, one tropical, the other boreal; the one enabling us to picture Yorkshire clothed with luxuriant vegetation; the other with the icy stillness of Greenland.

Mr. W. H. Gill, who is well known to possess a host of splendid Carboniferous fossils, brought some of his finest, including Halonia regularis, Lepidodendron (several species), Calamites (several species), Dadoxylon, Sternbergia transversa, Trigonocarpum, Sigillaria organum, &c., Goniatites Listeri, Aviculopecten papyraceus, &c.; from the Mountain Limestone, Lithostrotion, Lithodendron, Astræa, Spirifera, &c.; many species of ammonites and belemnites from the Lias; from the Speeton Clay, a good example of Meyeria ornatus; the Chalk was represented by Ananchytes, Spatangus, Galerites, &c.; and from the Oolite of Filey Brigg, where Mr. Gill has so long and perseveringly worked, a large number of fossils were shown.

Mr. C. D. Hardcastle's numerous cabinets had been requisitioned for this evening, and his exhibits consisted of gems and precious stones. These from their sparkling brilliance and unique character were very popular with the members, and Mr. Hardcastle's practical descriptions of the exhibits added greatly to the interest. He has constructed a case, with compartments, containining 70 precious stones and gems as a model of the High Priest's breastplate, or the Urim and Thummim; another handsome case, with twelve compartments, containing 48 precious stones, to illustrate those which in 21st chap. Revelation are metaphorically said to garnish the foundations of the New Jerusalem. He had also 100 specimens of topaz, garnet, &c., 95 of sliced and polished agates, 35 of onyx and chalcedony cameos, 35 of carnelian, chalcedony, &c., 40 of nodular agates, and 60 of various crystals, geodes, &c. He also showed a fine

specimen of labradorite, with its iridescent hues, and a number of the matrices or immediately surrounding rocks in which precious stones are found, the latter being extremely interesting geologically.—Mr. John Ingleby, who has spent many years in Ceylon, brought several of the mineral productions of that island, including that peculiar mineral known as laterite or cabook, plumbago, mica, auriferous quartz, tourmaline, &c.—Mr. T. W. Gray exhibited some pebbles he had obtained at the Point of Ayre, Isle of Man, including a nodular agate, &c.

The whole evening might have been profitably spent in the careful examination of these numerous exhibits, more particularly as the same were well described, but time rapidly passed, and therefore the President asked for an adjournment to the new rooms, where Mr. Godfrey Bingley was ready with his

EXHIBITION OF LANTERN SLIDES,

which was, in the unanimous opinion of all present, the best they had seen. Messrs. Bingley and Bedford have recently spent a brief holiday at that pleasant little watering-place, Grange, and, as all true geologists do, have knocked about with the hammer and used the camera. We had, therefore, a succession of views of that district, which, although varied, were geologically very valuable. Beginning by putting a copy of the Ordnance Survey map upon the screen, views of Grange and environs, the Windermere Road, Humphrey Head, Whit-barrow Scar, Hampsfell, &c., were shown. Then followed a series showing a number of erratic blocks in the vicinity of Grange, which were not only admirably photographed, but Mr. Bedford had also carefully measured each block, examined it for striæ or grooves, and described its shape and lithology. Certainly a mass of valuable information from this district. Views of old sea-worn cliffs, once beaten against by the waves of Morecambe Bay, a series to show the denudation of various escarpments, examples of limestone with deep furrows both horizontal and vertical succeeded, followed by a most beautiful set to illustrate the celebrated erratics at Norber, near Clapham. The grand scenery of Malham and Gordale was thrown upon the screen, and also a great number of views illustrating the cliffs, the wykes, the bays, the towns and villages upon the Yorkshire coast from Flamborough Head to Huntcliff. Leaving geology a little, Mr. Bingley was prevailed upon to exhibit a few of our northern Abbeys and Priories, taken from many points of vantage and exhibiting their chief architectural beauties. Thus Fountains and Furness, Kirkstall and Bolton, Whitby and Eggleston, Guisborough and Cartmel, and others were passed before the members.

Owing to the limited time, the President, in his Inaugural Address, confined his remarks in great part to the work and progress of the Association. After alluding to the new Rooms, and mentioning the kindness of the directors of the Leeds Mechanics' Institution, which all the members warmly acknowledged, he spoke of the universal pleasure and gratitude felt at the recovery of our valued friend and frequent leader, Mr. B. Holgate, F.G.S. He also referred to the high character of the new syllabus, and mentioned that the British Association had again admitted our Association as a Corresponding Society, which gave the privilege of direct representation at the recent meeting at Newcastle. He also spoke of the special work some members were engaged in upon the Geological Section of the Yorkshire Naturalists' Union and upon the Yorkshire Boulder Committee. As to the progress numerically, he alluded to the fact that, whereas in 1884 the register of members stood at 30, it had now reached 140.

During the time when Mr. Bingley was exhibiting his views and also afterwards, Mr. Bedford gave a short description of the Geology of Grange and District. He spoke of the picturesque character of the district, its fine climate, and its peculiar interest to geologists. The view from Hampsfell just behind the town is very extensive and varied, and Mr. Bedford described in detail the scenery around. Speaking of Hampsfell, he said it exhibited wide tracts of weather-beaten and water-worn limestone, with fresh green grass filling up the interstices. Looking across the valley to Lindale we see a range of hills of which Eller How is most prominent, a dark brown mass of rock, with vegetation of the same colour. This range is of the Silurian formation. After describing Whit-barrow Scar, with its "screes," he referred to the numerous erratics lying on Hampsfell, along the western edge, and at the northern end. Their composition varies considerably; there are masses of Volcanic Breccia, Silurian and Cambrian Grits, and Mountain Limestone. The origin of these erratics was discussed, and he said the evidence goes to prove the existence of large glaciers filling up the valleys leading into Morecambe Bay, from the north and north-west. Not only have the valleys been quite full of ice, but there is little doubt that, before the glaciers dwindled away, they surmounted the smaller hills of the district. The position of the stream of erratics leads one to believe that the motion of the great glacier was from the north-east, and that its path was diagonally across the smaller valleys of the district. This terminated an evening, memorable in the annals of the Association, and full of enjoyment and instruction.

NOVEMBER 21ST, 1889.

Mr. J. E. BEDFORD, F.G.S., the President, in the Chair.

"ATMOSPHERIC CIRCULATION,"

BY MR. W. LOWER CARTER, M.A., F.G.S.

(Abstract).

After some remarks by Mr. Carter upon atmospheric pressure, the atmosphere itself and its composition were considered. The air is in constant motion, and these movements, according to their intensity, receive different names, still they may be all summed up in one term—wind. Winds are convection currents, or movements caused by differences of density in adjacent areas of the atmosphere. They are really attempts to equalise the atmospheric pressure all round the globe. The heat of the sun is so distributed on the surface of the earth as to produce a general circulation of air between the poles and the equator, but modified by the distribution of sea and land, and by the elevation of tracts of land above the sea level.

Mr. Carter then considered the great systems of winds, and referred first to those due to unequal heating of land (as of mountain and valley), next to those due to the unequal heating of land and sea (from the high specific heat of the latter), and to the Monsoons; thus in the latter the ascending currents of hot air in summer from the high plateau of Central Asia cause the summer Monsoons, whilst the descending currents of air upon this table land when it is covered with snow and ice in winter, also produce corresponding winds, but of course in a contrary direction. There are also wind movements chiefly due to great evaporation. This is naturally produced where the sun's power is greatest, or in the tropical belt. Here there is a very wide expanse of ocean, which forms a sort of cauldron in which the vapour is produced supplying a great part of the earth with moisture by means of winds. In this extensive evaporation area there is a constant upward movement of air, highly charged with aqueous vapour; this current probably attains the height of seven miles, as clouds have been seen at that elevation. As this vapour-laden air rises, great expansion takes place, and consequent cooling, and hence there is much deposition of moisture in the liquid form. This change is accompanied by the production of great heat, due to the liberation of the latent heat of the vapour; this causes energetic air movements to take place, also accompanied by the production of

electricity. Hence rains, hurricanes, and thunderstorms enliven this area, which is called by sailors the "Doldrums," on account of the general absence of wind, and the hot, steamy, enervating atmosphere. Leaving the equatorial belt of calms and going northwards, we come into that region where the winds blow regularly north-east, these are the Trade Winds; the next is the belt of Calms of Cancer and then the south-west winds or Anti-trades. These are our prevalent winds in England, and derive their warmth and moisture from the Gulf Stream. Going southwards from the equatorial belt we find similar gradations and changes in the atmospheric currents or winds. The diagram which the lecturer exhibited, clearly showed a general section of atmospheric circulation. Evidence of upper currents in the atmosphere was next dwelt upon, as shown by the fleecy clouds known as cirrus, which at their high elevation have a different movement from the lower clouds. Dust ejected from volcanoes often reaches higher regions and is borne far away, as shown by records of eruptions in Iceland, Guatemala, and Java, when dust and ashes were carried hundreds of miles. Dust from the great African desert is carried up by hot currents and travels hundreds of miles, falling on the countries round the Mediterranean, and as far west as the Canary and Cape de Verde Islands.

Mr. Carter then described the method of determining and mapping the circulation of the atmosphere, saying that we have observed that atmospheric currents are caused by differences in pressure in adjacent areas, the air flowing from the area of highest pressure towards that which is lowest. By the barometer we are able to discover with great accuracy these differences in pressure. In mapping the pressure at any hour, observations are taken at numerous stations over the area in question, and lines are drawn connecting all points which are found to have the same pressure. These lines of equal barometric pressure are called isobars, and map out the area into tracts of higher and lower pressure, resembling the contour lines by which surveyors indicate the elevations of a hilly country. The position and shape of isobars over any area varies hourly, showing movements in the atmosphere of which we should only be dimly conscious without the aid of the barometer. These isobars generally appear in one of seven well-defined forms, each of which indicates special atmospheric conditions, thus—Low pressure: cyclone, secondary cyclone, and V depression; high pressure: anti-cyclone, wedge, col, and straight isobars. These forms were then detailed and may be briefly noticed. The cyclone is so called from its nearly circular form or distribution of isobars, and is the cause of our stormy weather. The lowest pressure is in the centre, hence it is called a depression.

The isobars are close together, and the movement of the wind is rapid and independent of the onward progression of the cyclone. The surface wind blows round the centre, contrary to the direction of the hands of a watch, in the northern hemisphere, and curves inwards. The upper currents flow outwards, so that evidently we have a revolving upward current at the centre. The anti-cyclone shows an irregularly oval distribution of isobars with the highest pressure in the centre; the isobars are widely apart, and the circumstances of the wind are exactly opposite to those just related, hence we have a descending central current of air. The motion of the wind is light, and the anti-cyclone is often stationary, and gives us in summer clear, bright weather, and in winter fair, but foggy and cold. The other forms of isobars are modifications of these two.

Mr. Carter, after thus reviewing the various forms of atmospheric pressure, and the circulation of wind attending each, noticed the varying force of the wind, which depends not on the shape of the isobars, but upon their nearness to one another, that is on the steepness of the pressure slope. To represent this slope the engineering term gradient is used. The gradients run at right angles to the isobars, thus the force of wind is governed by the relative difference in barometric pressure between two places, and not on the absolute barometric height. In a cyclone, the isobars being close, the gradient is steep and the winds strong. In an anti-cyclone, the isobars being far apart, the gradient is gradual and the winds light. Reference was then made to the general types of pressure distribution which have been recognised in the North Atlantic area, followed by details of variable winds and storms, as squalls, thunderstorms, line squalls, whirl-winds, tornadoes, blizzards, &c. The Lecturer, in conclusion, summarised his facts and arguments, saying that we have seen that atmospheric circulation consists of convection currents, caused by changes of temperature, which alter the density of the air, and vary the amount of aqueous vapour it contains; that this circulation is from equator to poles, with return currents; that there is a general symmetry about the equator, and that the direction of the wind movements is considerably modified by the rotation of the earth; that the whole atmosphere is broken up into circulatory systems, in some of which the movement is upwards and in some downwards; that each of these systems has its own particular weather, associated with characteristic forms of isobars; that the force of the wind in these systems depends on the closeness of the isobars to each other, whilst its direction depends on their shape; and that independently of these regular systems there are numerous winds of great violence whose origin is still obscure.

DECEMBER 5TH, 1889.

Mr. J. E. BEDFORD, F.G.S., the President, in the Chair.

"A REMNANT OF PRE-GLACIAL ENGLAND; OR HOLIDAY NOTES ON THE CROMER FOREST BED," BY Mr. A. FARRAR, F.G.S.

(*Abstract*).

Mr. Farrar commenced with a description of Cromer.—"Imagine a small, old-fashioned town or large village, clustered about a church with a lofty tower, and situated on a low cliff, to whose face the seaward part precariously clings; on each side higher cliffs curving outwards in an unbroken line, commanding the most extensive prospects of the sea, and having at their foot miles of good firm beach; behind them a country carved into shallow valleys, and low, rounded, heath-capped hills, with fertile cornfields, rich woods, 'stately homes,' and high church towers. With all these you have a soft, genial atmosphere, which thus constitute its claims as a seaside resort; for, as yet, it is innocent of the more mundane 'attractions' of its larger and more ambitious rivals." The portion of the coast described extends a distance of about 14 miles east and 6 miles west of Cromer. The cliffs consist at their base of Newer Pliocene strata, and, overlying them, a great thickness of tenacious blue boulder clay and incoherent glacial sands and gravels. They attain their maximum height (from 200 to 250 feet) about four miles east and west of the town, beyond which they gradually drop, and at the eastern end give place to banks of blown sand. The entire escarpment forms a bold, curving sweep, without a single bay or point to break it. Under the combined action of atmospheric and marine denudation the cliffs are being constantly broken up and swept away by the sea. The upper portions being, however, more friable and loose, atmospheric denudation (aided also by the action of springs) is more rapid than that caused by the encroachment of the sea, and hence the cliffs at their base are much obscured by talus. So rapid is the washing away that the loss is estimated at as much as two to three yards per annum on the average. The Pliocene beds here owe their importance to being the uppermost in the long succession of strata deposited previous to the "Great Ice Age," and so giving us a glimpse of one of the last stages of the constant changes which the physical geography of this island underwent before it acquired its present outlines. Underlying the Glacial and Pliocene strata is the Upper Chalk, but very little

of it is to be seen above sea-level. West of Cromer it is exposed on the foreshore at low water, but eastward it disappears owing to a slight slip. Above this the Tertiary strata are unrepresented until we come to the Newer Pliocene, the lowest member of which is the Weybourne Crag, a marine bed of shelly sand and clay, of which little could be seen, except in patches on the foreshore between East and West Runton.

Next come the "Forest Bed" series, divided into a Lower and Upper Freshwater Bed, with an estuarine deposit between—the so-called "Forest" or Elephant Bed. Of these three, the Lower Freshwater is, in extent, the most limited, as it is *in situ* in only a few places; it is a tenacious and very carbonaceous or peaty river mud, with bones of fishes and seeds of plants. The middle division is the one more particularly known as the "Forest" Bed, due to the stumps of trees found in large numbers in it, and which many of the earlier geologists described as being *in situ*; this was supposed to indicate the existence of an ancient land surface, on which the trees grew, but more careful examination in recent time showed that such could not have been the case. Messrs. Reid and Savien state that out of many hundreds of stumps examined by them, not one could be said to be *in situ*, many being bottom upwards, and trunks of trees were even found under them. They also state that the so-called soil is laminated, undisturbed, and unweathered, and that in every case the roots of the stumps are broken off and the ends frayed. All these facts lead to the inference that they were drifted into their places. The upper part of the Forest Bed may more properly be called a land surface, as in many places it has weathered into a soil penetrated by roots, and hence named the Rootlet Bed. This, where it exists, forms the dividing line from the next division, the Upper Freshwater Bed. The Forest Bed is estuarine in origin, and furnishes good illustrations of this kind of deposit. Its most typical characteristic, and by which it is easily recognised, is that of a compact gravel full of pebbles (flint, quartzite, clay-ironstone, &c.), rolled lumps of clay, and coarse sand. This gravel is often cemented into a ferruginous conglomerate termed "pan," which is extremely hard, and on that account is often conspicuous at the base of the cliffs, especially at Runton. The Forest Bed, however, varies in its character, as in some places it is a false-bedded gravelly sand, in others a fine loamy sand or laminated blue clay. This lithological variation is, however, what may be expected in a series of fluvio-marine deposits. Its thickness is as much in some places as 20 to 24 feet, but its average thickness is about 10 feet. The Upper Freshwater Bed (which lies in eroded hollows of the estuarine beds or on the Rootlet Bed) is seen in one of the

most typical sections at Beeston, west of Cromer, as a dark-blue peaty clay very full of plant remains. More usually, especially east of the town, it is composed of light sand, with a greater or less proportion of loam, or blue carbonaceous clay, often in irregular bands, that give the beds quite a veined character. The next and uppermost of the Pliocene Beds is known as the Leda Myalis Bed, and is a marine deposit of fine loamy sand from 10 to 20 feet thick, and is best seen west of Cromer.

Mr. Farrar next described at length the fauna of this period, enumerating Elephas antiquus, E. primigenius or Mammoth, E. meridionalis, Trogontherium (a gigantic kind of beaver), Cervus (several species), Rhinoceros, Hyæna, Sabre-toothed Tiger, Hippopotamus, Glutton, Great Cave Bear, Sperm Whale, and many others. Truly an extraordinary collection of animals to the Englishman of to-day, and more valuable as it exhibits a fragment of the last pre-glacial epoch. Of the flora, some 60 species have been collected, mostly in the form of seed or fruit, and include many with which we are familiar, all being existing species save two, which are extinct in Britain, viz., the Water Chestnut and the Spruce Fir. In reviewing this concentration of so many diverse forms within so restricted a horizon, Mr. Farrar said it confirms the evidence which the lithological character of the beds gives of estuarine conditions of deposit, or, in other words, the existence of a river with a large tidal mouth. Quoting Mr. Reid, who has carefully worked out the history of these beds, he considered this river as the most important feature of the period, and from evidence based on the composition of the gravels, believes it to have flowed from the south-east, and to be in fact no other than a prolongation of the Rhine, during the period when the southern part of the North Sea (even now comparatively shallow) was land, thus uniting England to the Continent. At the beginning of the Forest Bed Series, the land was sufficiently above sea level for the peaty Lower Freshwater Bed to be deposited. A slight subsidence allowed the peat to be bored by Pholas, broken up and re-deposited in the Forest Bed which was then forming—a state of things similar to the deposits now forming over the submerged forests of our present estuaries. Reverting to the question of the tree stumps, it was at this time that they would be drifted down the river and deposited in the estuary; this being filled up and another slight rise, we have the land surface, of which the Rootlet Bed remains as the evidence. This land surface formed a wide alluvial plain, bordered by rising ground where trees grew, and dotted with large shallow lakes, in which the Upper Freshwater Bed was deposited. It was not unlike the district of the "Broads" at the present time, and

many of the shells (such as Unio) now living there are also to be found in ancient lake bottoms. The overhanging marine beds indicate a subsidence. These oscillations of level (whatever the cause) were probably local, and mere incidents in the greater movements to which we owe the present distribution of land and water.

With regard to the flora and fauna, we may note the contemporaneous existence of a temperate flora, a southern or sub-Arctic fauna, and a decidedly Arctic marine fauna. This indicates a transition from the warm tropical climate of Eocene and Miocene times to the cold Pleistocene period. Messrs. Prestwith and Reid consider that the marked dying out of southern and the increase of northern forms in the marine fauna may be due less to climatal changes than to the action of northern ocean currents, those from the south being barred by the rising land, which, aided by the increasing cold, not only prevented the migration of southern marine forms, but also formed a highway for the land and fresh-water fauna. Still the approach of the Ice Age and the consequent changes in the climate, must have ultimately determined the fate of the tropical marine forms; but from the character of the flora it is thought that the climate during the deposition of the Forest Bed did not differ much from that of the present time. Above the marine bed referred to, and under the boulder clay, there is a fresh-water deposit, in which Arctic species, as the Arctic Willow and the Dwarf Arctic Birch, have been found. This is considered to indicate the lowering of the temperature by 20 degrees—an unmistakable sign of the coming change. The Glacial Age led to the extermination of many of the large mammalia, most of which were herbivorous, and hence could not have survived the change in the vegetation which necessarily followed as the climate became colder. By far the greater part of the cliff consists of a great accumulation of boulder clay, sands, and gravels. The boulder clay which forms the base of the drifts frequently has a laminated appearance, due to the effects of sliding pressure. These drifts have a peculiarity, not to be seen elsewhere in Europe, save in the Island of Moen, in Denmark. They are crumpled, twisted, and folded in an extraordinary manner, and hence are collectively known as the Contorted Drift. You cannot walk along the coast without seeing these contortions in all degrees of complication, especially in the sandy deposits, here folded into the form of an S, there in sharp undulations, and elsewhere violently thrown up until they stand on end, or are even inverted, The clay is not so disturbed, but one often sees in it fine lines of folding that remind one of the schists of the Scottish Highlands.

After detailing the effects on the Chalk of the same force that produced these contortions, which have three distinct features, Mr. Farrar reviewed the theories which have been brought forward to account for these exceptional features. One theory attributes them to ordinary upheaval and subsidence, or, in other words, deep-seated disturbances, but to this there is the fatal objection that the Pliocene beds beneath the contortions are generally quite undisturbed. Another would refer them to subsidence through the action of landslips and similar movements. A third, adopted by Lyell, accounts for them by the action of icebergs and coast ice. Mr. Reid, however, advances as a tentative view of the matter, that the contortions are due to the dragging effects of the heavy sheet of land ice which overspread northern Europe during part of the Glacial Period. That this view is coming to be accepted, is seen in the presidential address of Dr. James Geikie to the Geological Section of the British Association, where, referring to similar disturbances to those mentioned, he attributed them "to tangential thrusting or crushing," and considers that the only agent that could produce such appearances is land ice. But we are to a large extent dependent on the present processes of Nature for a clue to the past, and our knowledge of the effects accompanying the action of a great ice sheet (especially over a comparatively level country like East Anglia) is so limited and founded so much on *a priori* considerations that there is room for caution. The discoveries of Dr. Nansen and others may afford us opportunities of arriving at a clearer understanding of the problems presented to us by the Cromer cliffs.

An interesting discussion on the various points raised in the paper, more particularly on the question of contorted drifts, also took place. The President paid an eloquent tribute to the memory of Mr. James Abbott, who, although not a member of the Association, yet had done so much for many years in Leeds to promote the interests of science.

DECEMBER 15TH, 1889.

Mr. C. D. HARDCASTLE, Vice-President, in the Chair.

"MINERALS AS GEMS AND PRECIOUS STONES," BY Mr. S. JEFFERSON, F.C.S.

Mr. Jefferson, after alluding to the fact that while most of the members in their study of geology preferred the examination of sections in the field, and others enthusiastically devoted themselves to the collection of fossils, said some loved to possess

those beautiful minerals used as gems and precious stones. And much is to be said on behalf of the latter class, as they really combine art and science in their research. These beautiful minerals, which have been called "sparkling blossoms of the rock," have been objects of the deepest interest and fascination to mankind from remote ages. The Egyptians of far-off days have left us evidence of their skill in the manner in which they engraved the scarabæus and other sacred objects upon these hard stones; indeed, the age of the mummies, beside which they have been found, takes us back to an extremely remote period, historically speaking, and fills us with wonder at the knowledge and high civilisation that that mysterious people even then possessed. The cameos and intaglios of ancient Greece and Rome, also excite our deepest admiration. In Holy Writ, too, frequent allusions are made to precious stones and their beauty, which are well known to all; the Iliad and Odyssey likewise contains descriptions of jewels. The ancients, however, looked upon these special minerals more supernaturally than we do; it has been said that they were esteemed by the philosophers of old as "living beings." Modern science has stripped off this sentimentalism, and now inquires into their origin, fixes their geological position, and examines their optical properties and their chemistry. There is another aspect of the value of gems, that is their connection with religion, both in ancient and modern days; the high priest Aaron had his breastplate adorned with them, and so has the modern bishop his pastoral staff. Votive offerings of gems were made in the temples of Jupiter and Juno, and so did they accumulate in the treasuries of christian cathedrals. Those minerals which are used as gems and precious stones possess several well-marked characters, by which we estimate their value. Thus their beauty comes first; this is due to their brilliancy or reflective power, to colour, and to that property of flashing forth the prismatic colours so clearly seen in the diamond and the opal. Writers generally term this refraction, but it should more correctly be named dispersion, for that includes both the cases in which white light is broken up—in the diamond from the so-called refraction, and in the opal from diffraction. The quality of hardness is another factor to determine the value of these minerals; this is indispensable, as it is obvious the friction by wearing would soon remove their polish. The old Egyptian lapidaries were alive to this quality of hardness, as their productions have come down to us so unchanged. Another quality of value is rarity. Thus large rubies are very scarce; hence when a perfect ruby weighs five carats (really 16 grains troy) it is worth double a perfect diamond of the same weight, but if ten carats in weight, then it is treble the value.

The chemical composition of these special minerals was next alluded to, the three important constituents being carbon, alumina, and silica. The diamond is crystallised carbon, nearly pure, as when burned only about the two-hundredth part of ash is left. It has been known from the time of the ancients, and was termed adamant, from the Greek word "adamus," signifying unsubdued or indomitable. This refers to the fact that no other substance can scratch it. There is, or rather was, a common error that it cannot be broken. Pliny made especial allusion to this test, and it was long believed; thus, after the battle of Morat, when the Swiss seized upon the diamonds of Charles the Bold, they tested them with hammers, which completely destroyed them. The diamond is brittle, and a smart blow with a hammer will prove it directly. The form of the crystal, as found in nature, is an octahedron of eight equilateral triangular faces, or some modification of this form. The lecturer showed specimens of the matrix in which the gem occurs from South Africa; in one piece the triangular face of a small diamond was seen gleaming forth, in another was the cavity from which a Leeds man in August, 1884, dislodged a fine stone of 27¼ carats; this cavity showed the impress of four of these triangular faces very clearly. This rock, which is a porphyritic peridotite, containing calcite, was named Kimberlite by the late lamented Professor H. Carvill Lewis. He looks upon it as an eruptive and post-carboniferous rock, eminently basic, enclosing, however, "a large amount of the adjoining bituminous shale which has been more or less baked and altered. It is a volcanic breccia, but not an ash or tuff, the peculiar structure being apparently due to the successive paroxysmal eruptions." May not the vegetable matter that formed the probable source of the crystallised carbon have lain in this shale? After referring to parts of the world whose geology is fairly well known, such as Borneo, the Urals, Bohemia, New South Wales, &c., where diamonds are found, and in every case in connection with serpentine, Professor Lewis reviews his facts and concludes that those so far collected indicate serpentine, in the form of a decomposed eruptive peridotite, as the original matrix of the diamond. The genesis of the diamond is yet a matter to be solved, and the lecturer propounded the theory that some fossil resin, like amber, has by the action of pressure, some degree of heat, and, perhaps, also from electric currents in the earth, been so modified that the carbon atoms only have been left; these through untold ages, have arranged themselves in obedience to molecular forces until the diamond has resulted. The lecturer pointed out the analogy (which, to his knowledge, no writer has yet done) between the changes that coal undergoes and the probable changes that resin

passes through to form the diamond. Then followed an interesting account of some of the chief diamonds of the world, particularly mentioning that historical one known as the Pitt or Regent diamond, of which a model was shown. This is considered of matchless brilliancy, and weighs 137 carats. It has long been identified with the fortunes of France, and has passed through some strange vicissitudes. The Koh-i-noor or "Mountain of Light," now in the possession of Her Majesty, was also described. It, too, has a long and varied history, stretching away, according to Hindu tradition, in the past for 4,000 years. The Orlow diamond, which ornaments the Imperial sceptre of Russia, weighs 193 carats. Its history is also striking, as it formed one of the eyes of a famous idol in an Indian temple. It was forced from its socket by a French soldier. The other was similar but could not be extracted in time. Wilkie Collins's novel of "The Moonstone," was suggested by this stone. The so-called Braganza diamond, which weighs 1,680 carats, was mentioned. This diamond is in the rough, and is not allowed to be examined. It is held, however, that it is but a topaz, in which case its fabulous value is baseless.

The ruby is the most valuable of gems, and, curiously enough, it is composed of the rust or oxide of that abundant and useful metal, aluminium. Just as the oxygen of the air produces the red rust or oxide upon iron, so it produces from aluminium the white rust known as alumina, which is the principal constituent of common clay. It seems as though the pasty, tenacious clay is the antithesis of the brilliant and peerless ruby, but it is only in form. This alumina, when crystallised and tinted with a salt of iron in the ferric state, is known as the ruby. By iron in the ferrous state the ruby is sometimes, but very rarely, coloured green. The various rubies were detailed—the Oriental ruby, which is almost entirely pure alumina, and a hexagonal prism, terminated at each end by six-sided pyramids; the Spinel ruby, which contains, in addition to the alumina, also magnesia and silica, and with octahedral crystals; and the Balas ruby, which is a variety of the Spinel, but coloured by the oxide of chromium. A fine specimen of the latter, now in the English Crown, was worn by Henry V. at Agincourt. The sapphire is a splendid gem, also composed of alumina, like the ruby, and coloured by metallic oxide. To the ancients it was above all gems, and there are some quaint and supernatural traditions connected with it. (See St. Jerome's works). According to Epiphanius, the tables of the Law as given to Moses were wrought in this stone. There is one variety, shown by the lecturer, in which, when light is reflected upon it, is formed a star of six rays in a most beautiful and

remarkable manner; this is known as the asteria or star sapphire. There is great veneration in the East for this stone, and the owner of one can always command profound respect. The blue of the sapphire is owing to the presence of cobalt. The well-known and beautiful gem, the emerald, is rather more complicated in its composition, as in addition to the silica and alumina, it contains about 15 per cent. of glucina, and is coloured green by the oxide of chromium. The aquamarine is really the same as the emerald, but its paler tint is due to the presence of iron. The ancients thought highly of the emerald, and many allusions are made to it in their works. Pliny says :—"There is no colour so pleasing to the eye as that of the emerald. Whoever delights in the verdure of herb and leaf must enjoy infinitely more the contemplation of emeralds, for no verdure can compare with theirs."

The lecturer next described the opal, which is an amorphous form of silica, or flint, with about 10 per cent. of water, which gives it a rich internal iridescence. This gem was held in the greatest admiration in former days; it was said by the great Pliny to be made up of the glories of the most precious gems, as containing the gentler fire of the ruby, the brilliant purple of the amethyst, and the green of the emerald, all blended in a startling and magnificent combination. In addition, it was held to possess supernatural powers, as, for instance, that of invisibility, like the ring of Gyges. Specimens were exhibited, both in the rough state and polished, displaying the colours by diffraction very beautifully. Next was described the moonstone, an opalescent variety of adularia (which means literally "sweetly fair") or transparent felspar. The topaz is a fluo-silicate of alumina, and is one of the best known of our gems. The garnet is a beautiful stone, but lacks the essential of rarity, although it has hardness, brilliancy, and rich colour. The garnet varies much in colour and also in chemical composition; some, in addition to silica and alumina, contain protoxide of iron, others lime, oxide of manganese, &c. One variety of garnet when cut *en cabochon* or in the rounded form is the carbuncle. They are widely distributed among the rocks, being found in granite, gneiss, mica schist, serpentine, crystalline limestone, &c. The torquoise is a fine opaque and beautiful stone, and is a hydrated phosphate of aluminium, iron, and copper. This gem has been held in the highest estimation in the East for many centuries; indeed some mines in the Sinaitic Desert (where this mineral occurs in nodules enclosed in red marl) are said to have been worked at the time of the building of the Great Pyramid. The ancients believed that this gem would draw upon itself any trouble which threatened

the wearer. Mr. Jefferson then mentioned some varieties of precious stones, less valuable than the preceding, as the agate, onyx, &c. These are mixtures of crystalline and amorphous silica in concentric layers. The agates have long been known to the engraver of gems for the splendid examples of his art which he can produce upon them. The onyx is that variety of agate which has bands of colour regularly and sharply defined in white and black, grey or brown.

Crystals and specimens, many of the former wonderfully perfect in their form, were shown by the lecturer, and received close attention as well as warm admiration. The varieties of tint in several examples of topaz, and the varying depth of colour in some amethysts were very noteworthy. Some successful and instructive experiments were made to illustrate the colouring of gems, in which solutions of silica and alumina were tinted by metallic salts.

FIELD EXCURSIONS.

EXCURSION TO GARFORTH AND NEWTHORPE.

MARCH 16TH, 1889.

Leader, Mr. B. HOLGATE, F.G.S.

In commencing the series of field excursions contemplated for 1889, it was thought desirable that the intention carried out in part last year, of examining those little known but interesting rocks comprised in the Permian system, should be continued. Mr. B. Holgate, F.G.S., who has so kindly offered to conduct this series of excursions, was again in readiness with his stores of practical information upon the district, geological and otherwise. The members were favoured with magnificent weather, it being one of those bright and bracing days in early spring, the fresh and westerly breeze stimulating and invigorating in the highest degree.

En route the leader drew attention to the varied objects of geological interest. It was refreshing after passing through the uninviting and murky district of East Leeds, succeeded by the dismal tunnel, to enter a country of a totally different aspect, and view to the south the alluvial plain of the river, and on the east the wooded heights of Templenewsam and the bold escarpment of Slack Bank. Soon after emerging from the tunnel we passed over the fault or dislocation of the strata known as the Osmondthorpe Fault. This runs from Seacroft, through Osmondthorpe, to Hunslet, and at the second-named place has a down throw of about 50 yards to the south-east; but this, of course, varies in other parts of the line of fault. We were now upon the lower part of the Middle Coal Measures, and soon entered a cutting through the Slack Bank Rock, that thick sandstone below the Middleton Main Coal, which derives its name from the steep ascent of Slack Bank which is composed of it. As we passed on, the strata dipped gently to the south-east, thus showing we were travelling gradually higher in the geological record. Crossgates was passed, and in the cutting could be seen exposed a fine section of the Middleton Main Coal. The sandstones showed good examples of current bedding in some places, and in others sandstones and shales seemed to dovetail into each other. We now entered upon the Magnesian Limestone, and the leader pointed out the difference in the colour of the soil arising from this fact. As we passed over the Coal Measures, the ploughed fields were of a black or yellow colour, and this had now changed into a rich warm brown or red.

At Garforth Station the party alighted, and were met by Mr. George Burlend, of the Newthorpe Lime Quarries, and Mr. Walker, of Brierlands, whose instruction and guidance were highly valued by all. Pursuing the road, the spot was pointed out where the "quick-

sands" occur; they also crop out at Parlington Park end and at Garforth Cliff. These beds, known as "quicksands" from their soft nature, occur at the base of the Lower Magnesian Limestone in several localities, and when of a fine nature have been obtained for moulding sand. We now visited the Brierlands Quarry, which has been extensively worked. The Lower Limestone here is thinly bedded, with marly partings (locally termed "spasms") between. These partings were rich in that well known Permian fossil, Axinus obscurus, of which some of the members gathered large quantities. In one part of the quarry was noticed an up-throw (termed locally a "trouble") of a limestone having a more dolomitic character than the beds into which it had been thrust.

Passing by Stourton Grange, the fields were crossed, and soon we were upon the famous road which has existed for so many centuries, the western branch of the old British highway, the Ermyn Street. At the point we were at it runs in a straight northerly direction through Aberford, and certainly is a striking feature in the landscape. Here, too, is an artificially made earthwork or embankment known as the "Ridge" (locally as the "Rig"), it is on the east side of the road, and we were told was formerly two miles long. It is also named the "Soldier's Hill," and some remains, as horse shoes, &c., have been found as it has been gradually demolished. This immense defensive work must have been the result of an incredible amount of time and labour, and also will have been used in many successive wars throughout long past ages. When and by whom was it built? It seems to have been for the purpose of defence against the foe from the east, and at a time when, from the fact of the road passing through a dense forest, its capture would be more easily made. The commentator on Richard's Itinerary denominates this road a former British track-way, which, of course, the Romans in their wisdom were ready to use, and with their great skill to develop and strengthen, making it their chief military road to Tadcaster and York.

Leaving the road, we entered, a little to the south-east, a quarry known as Jerry Lane or Burlend's Quarry. Some good building stone has been got here, and it supplied the same for the erection of Micklefield Church. This limestone is much harder and more thickly bedded than the last we had seen, it was divided into layers by very thin partings of marl, and the surfaces were observed to be wavy in outline. The question was raised—was this the result of lateral pressure? or did we see here an old denuded surface, and these inequalities the result of weathering? The beds still dipped steadily to the south-east. This stone was noticed to contain many cavities lined with crystals of bitter spar. This was, too, the object of some discussion. Dolomite and Magnesian Limestone are generally admitted in some cases to have been formed by chemical precipitation, and in others by the alteration of limestones. There are many opinions as to the method in which the latter process, or dolomitisation, has been carried out. But Elie de Beaumont suggests that these

cavities result from decrease in the bulk which would accompany the transformation of limestone into dolomite. Thus he says water holding Carbonate of Magnesia in solution percolated through the rock; the tendency of this salt to unite with Carbonate of Lime caused it to be precipitated, and the carbonated water took up in its place Carbonate of Lime. Out of every pair of molecules of Carbonate of Lime one was removed in solution, and its place was taken by a molecule of Carbonate of Magnesia. Then by taking into consideration the atomic weight and specific gravity of the original rock and the rock produced, he shows that the shrinkage should be between 12 and 13 per cent. It must be mentioned that we were also shown between Brierlands and Jerry Lane some beds of a hard, compact, flinty rock, used for road metal. It broke under the hammer with a decided conchoidal fracture.

We now proceeded through fields to Micklefield, where we passed through the station and further along a footpath by the railway side to Newthorpe, the object being to visit the extensive quarries of Magnesian Limestone worked by the owners of Garforth Colliery, under the management of Mr. George Burlend. These quarries may be seen on the railway journey to Hull. Here is a splendid section of the Lower Magnesian Limestone, some 80ft. or 90ft. being exposed. It was very soft in some places, and varied, too, in colour in proportion to the Oxide of Iron contained. It is thickly bedded and intersected by many joints. There were several kilns in full operation converting the limestone into the well known commercial product. This lime is in great demand by builders, and also in gasworks for the purification of the crude gas. The various kilns were visited and the process courteously explained in detail by Mr. Burlend. He also kindly furnished an analysis of this limestone from different depths of this quarry made by Mr. Fairley, F.R.S.E. :—Moisture, 8·68; Carbonate of Lime, 50·59; Carbonate of Magnesia, 39·75; Oxide of Iron, 0·33; Alumina, none; Silica, 0·65; Alkalies, a trace. In one part of the quarry the beds were observed to show on their surfaces, above and below, a toothed structure; this peculiar outline has not yet been fully investigated, although theories have been brought forward. Similar surfaces may be noted on this limestone at Whitwell and other places in South Yorkshire and Derbyshire.

More time might very profitably have been expended in examining and studying this truly magnificent section, so full of practical value and information in every part, but time pressed and we must leave. After tea Mr. J. E. Bedford, F.G.S., the President, and Mr. B. Holgate, F.G.S., the conductor of the excursion, suitably acknowledged the obligations the members were under for the unvarying kindness shown to them on that day, and the privilege of examination and description of the Newthorpe Quarries. It was fortunate, also, that Mr. A. E. Nichols, with his camera, took some good views during the afternoon of the sections named, &c.

The members were also indebted to Messrs. Harrison and Routledge for the facilities afforded by them.

EXCURSION TO SOUTH MILFORD AND SHERBURN.

APRIL 13TH, 1889.

Leader, Mr. B. HOLGATE, F.G.S.

The members again explored last Saturday a district where sections of the Permian Rocks, better known as the Magnesian limestones and marls, could be examined. The excursion was under the leadership of Mr. B. Holgate, F.G.S., who certainly intends, from the method and clearness of his instructions in the field, that at the close of the series the members shall be fully acquainted with the stratification and the composition of these interesting rocks.

After passing the Newthorpe Quarries, the limit of the last excursion, the Lower Magnesian Limestone dipped under the Middle Marls, of which sections could be seen in the railway cutting, and these in turn and in like manner gave place to the Upper Magnesian Limestone. The party alighted at South Milford and speedily made their way to the good sections revealed in the Milford Quarry. Here the Upper Limestone is exposed; at the top it is thinly bedded and rubbly, then the stone is of a more compact character, being thickly bedded and massive; below the last-named beds the stone is again in thin layers. The thick limestone is of a greyish colour, very hard and in some places crystalline. In one part of the quarry under the grey limestone, and about seven feet below the floor of the quarry, the beds are of a reddish hue and highly fossiliferous. The activity of the members was well rewarded, and each had a trophy to exhibit in some weathered fragment, displaying on its surface, like a rich arabesque, the fossil remains of molluscs and algae. The thick limestone is quarried for road metal. This quarry proved so interesting that a considerable time passed before the members were willing to leave.

The road to Sherburn was then taken. We were now on the margin of the Magnesian Limestone; in an old quarry near the road side it could be seen dipping steadily to the east, and it soon disappears under the Trias of the Vale of York. From this road an extensive view could be had of this broad and fertile vale, presenting a rich scene of pastoral beauty with few, if any, parallels in England. The low hills of Brayton Barf and Hambleton Haugh were conspicuous, and in the far dim distance the Yorkshire Wolds closed the view. From Sherburn a detour was made to visit the Bishop's Dike, a straight waterway or drain which runs to Cawood on the Ouse, and which tradition asserts was the means by which the fine stone of Huddleston was conveyed to the Ouse, for further transport to York and Beverley for the erection of their great Minsters. The side of the Dike was traversed for some time, and some fields crossed to visit a spring known as the Tonking Well, which has a fancied or real repute as a remedy for scurvy.

The party next proceeded to the Stream Field Farm Quarry, where another fine and comprehensive section of the Upper Limestone is exposed. Although the dip was steadily to the east, yet dome-like bends, the result of lateral pressure, were well defined in some parts of the quarry. Being on the same geological horizon, the beds in their stratification and nature are somewhat similar to those described in the Milford Quarry. And now a temptation was presented to the members, to which they succumbed. All the afternoon the majestic tower of Sherburn Church had been a most conspicuous landmark, and although geologists in the field have little time, if any, to spare for archæology, yet it was felt that the historical and architectural renown of this church necessitated a visit. Hence field work was suspended, and the fields crossed and the hill ascended to the church. On our arrival in the churchyard the Vicar most opportunely made his appearance, and very courteously showed and explained both the interior and exterior of this celebrated edifice.

The church of Sherburn is of several dates and styles of architecture, ranging from Saxon to Perpendicular, and in passing round its venerable walls one could not help but muse upon the eventful scenes and changes it has witnessed. Probably when this site was the eastern limit of the small but ancient Kingdom of Elmete, and looked out upon the vast expanse of forest and fen which then filled the Vale of York, there would be some humble edifice here dedicated to the Cross, for did not Elmete preserve its Christianity? In Saxon days, when the great Mercian King Athelstan had his palace close by, a fine building would exist and a town would have sprung up around it. As the Vicar said, a magnificent peal of bells then existed and the church was only a degree below that of a cathedral. The worshippers at Sherburn are certainly to be envied when we reflect upon the associations around them, how the faith has descended intact upon this very site through so many centuries, and how that royal warrior, the victor of Brunanburgh, who did so much for Christianity in those early days, here bent his head in reverence. As days passed on, both church and town increased in grandeur and importance, for, as the Vicar observed, in Norman days the rateable value of Sherburn was nearly five times that of Leeds!

A view of the Norman nave with its massy pillars and fine arches, with characteristic mouldings, was particularly impressive, and also the Saxon arches over which the tower is built. The ancient and beautiful stained-glass in the western window, with its shields and mottoes, was attentively examined. A view of the church from this point, looking down the nave to the restored chancel, exhibits a striking *coup d'œil*. We were also shown in a chapel on the south side an ancient piscina and some recessed arches under the windows, which probably once contained effigies of the lords of the district. The Vicar pointed out, in a room leading out of the porch, a piece of carving rich in detail and idealism, a fragment, no doubt, of an ancient shrine, and which from the durable nature of the limestone has well preserved the sharpness of its outline. The porch, too,

is very fine, but appears at some time to have been reconstructed. An ancient cross in the churchyard was shown, and also the quaint old registers dating from 1639.

The time had sped so swiftly and pleasantly in the church that on leaving it was found impossible to carry out the remaining part of the programme, viz., to visit the famous Huddleston Quarry with that care it deserved, and therefore it was decided to make that the object of a future excursion. Accordingly the way was taken leisurely to Milford, and *en route* where the road was cut through the Upper Limestone the party was photographed by Mr. A. E. Nichols, who had during the afternoon taken several good sections with his camera. Mr. Burlend, of Newthorpe, again accompanied the members, and gave them the benefit of his local experience.

EXCURSION TO BROUGH AND ELLOUGHTON,

APRIL 22ND, 1889.

Leader, Mr. B. HOLGATE, F.G.S.

The Easter Monday of 1889 will be long remembered by those members who were present upon this annual field day, for the brilliancy of the weather, the practical character of the work engaged in, and the congenial manner in which the day was spent. A day's excursion gives the members more opportunity of studying those formations which lie too far away for the ordinary Saturday's outing, and when, in addition, the railway company grants extra facilities and reduced fares, it would be surprising if there was not a good muster. It was decided, therefore, that this excursion should be to Brough-on-the-Humber and vicinity, so that the Post Tertiary Gravels and also some of the Oolitic Rocks (the latter of which dip under the chalk of the Wolds) could be examined.

The excursion was again under that indefatigable and popular leader, Mr. B. Holgate, F.G.S., and the members had also the utmost kindness shown to them by Mr. Lyon, of Castle House, the proprietor of the gravel pits which the party had travelled thus far to see. The Council of the Hull Geological Society had also decided to join the Leeds hammermen, and thus when the two societies met upon the platform at Brough there was quite a formidable array of geologists, all bent upon learning as much as possible of the nature and conditions of deposition of the strata at the foot of the Wolds. Dr. F. F. Walton, F.G.S., the President of the Hull Geological Society, who has minutely examined every section in the district, was present, and the information he so freely imparted during the day added materially to the value of the excursion. It is of great importance that the members of these and other kindred societies should occasionally co-operate

in fieldwork and exchange observations; it increases their knowledge, enlarges their experience, and enables their various opinions to be made known.

As the train sped on in the beautiful April morning many familiar scenes were pointed out; the Newthorpe Quarries, Sherburn Church, Brayton Barf, and Hambleton Haugh were passed, and soon we were passing the fine old abbey of Selby. Crossing the Ouse, the remnants of Wressel Castle on the one side, and the lofty tower of Howden Church on the other, were noted. The calm, broad estuary of the Humber looked magnificent with the gleaming sunlight thrown across it, and presently the party, in the best of spirits, alighted at Brough in the midst of introductions and congratulations. We passed through the village and ascended the low eminence of Mill Hill, on the top of which a gravel pit has been excavated. This hill is really an Oolitic outlier, capped by Post Tertiary gravels, and there is a tract of low-lying ground between it and the Wolds. Mr. Lyon took charge of the party here, and conducted them to different parts of the pit, and also informed them that an immense curved tusk of the mammoth or Elephas primigenius had been discovered. It was said to have been about 13 feet in length when first uncovered, but, unfortunately, was in a very friable state and crumbled into fragments. A mammalian bone had just been bared, but it was impossible to determine it. However, instructions were left to avoid, if possible, a repetition of the catastrophe attending the former.

Mr. Lamplugh gives the following section of this pit :—Top soil, &c., $2\frac{1}{2}$ feet; rough stony gravel with some sand, containing pebbles of flint, sandstone, red chalk, oolitic limestone, and other local rocks, also a few well-worn erratic pebbles of felstone, quartzite, &c., also rolled lumps of clay and thin seams of clay and of carbonaceous matter, about 9 feet; yellow sand with stony layers, the stones included similar to those in the gravel above, about 5 feet; then succeeds some hard grey or whitish clays, probably belonging to the Estuarine Oolites, but thickness uncertain. In the yellow sand the mammoth's tusk was found. There was little to add to the above enumeration of pebbles found in this gravel by the members, but a large block of Mountain Limestone was broken, also many good examples of Gryphea incurva were obtained from the gravel. Flints, of course, were predominant. This pit showed splendid examples of cross bedding. The varying currents must have been swift, in fact, almost torrential. Here and there in the upper gravels "pipes," or roughly shaped pillars, descending from the top soil, are to be seen; these have probably been caused by the decomposition of tree roots and stems, the cavities being filled up with earthy and calcareous matter, which have since, by percolation of water, become very compact and hard, so much so, that we were told they could be left standing as pillars whilst quarrying or digging was going on. After a lengthened but deeply interesting stay in this pit, Mr. Lyon conducted the party to ascend the towers of his mansion close by, named Castle House. This was for the view to be there obtained,

which, as the house stands in a grand position on the summit of Mill Hill, is very wide and magnificent. In front we were looking over the fertile vale of York, with spires and towers of village churches dotted here and there; a dark pall of smoke indicated the locality of Goole; then could be seen the confluence of Ouse and Trent, forming the majestic Humber; very prominent, too, was the Oolitic escarpment at Whitton, in Lincolnshire; further east the chalk Wolds of that county; then, turning round, we had a fine prospect of our own Yorkshire Wolds. When standing on this vantage point, one must think of the scene in bygone centuries, when probably from this very hill the Roman general would watch the passage of his legions over the Humber, on their way from Lindum to Eboracum; for did not the eastern branch of Ermyn Street, coming direct from Lincoln to the Humber shore, continue again on the north shore at Petuariam or Brough, and proceed to the then imperial city of York?

Leaving the hill, and returning to the Ellerker road, we entered a small hollow, where there was an exposure of oolitic limestone, described by Dr. Walton as "flaggy, thin, soft, yellow, and irregularly bedded, with numerous fossils." Among others have been found Terebratulæ, Trigoniæ, Rhynchonellæ, Pinna, Modiola, &c. On the west of the road, a little further on, we entered the large Brough Gravel Pit. This had many points in common with the one we had visited at Mill Hill; the "pipes," however, were much more conspicuous and numerous. A large block of quartzite, about 3 feet in diameter, with outer surface slightly smoothed, was noted. In one part of the quarry, about 3 feet below the surface, the workmen had disinterred some human bones, accompanied by fragments of rude pottery, these probably, from the roughness of their make, being British. Some of the bones were examined, and as far as a hurried inspection could decide, were said to be portions of the pelvis and femur of a female. Recently a skull, with teeth in perfect preservation, was found in this quarry.

Further on a detour was again made from the road and the "Cockle Shell" Quarry visited. This would have been a most instructive section had it been possible to examine it, but, very unfortunately, the quarry was flooded, and hence only what may be termed a bird's-eye view could be obtained. Dr. Walton explained that the section we saw above the water level was rubbly oolite, 6ft.; compact limestone, 2ft. 6in.; thin, brown rubbly oolite, 2ft.; compact limestone, 3ft.; rubbly limestone, 10ft. Another small exposure of the Lower Oolites was subsequently examined, crossing some fields for that purpose. This was a good section, and some fine specimens were obtained of characteristic fossils of the Millepore Limestone. And now the bags began to be heavy and fatigue felt. Thus some of the party considered enough field work had been done, preferring to walk leisurely through the fine park of Mr. Christopher Sykes at Brantinghamthorpe on the return to Elloughton. Others more enthusiastic pressed manfully over the fields, passing Ellerker Mill on the way to another quarry. This is known as the Long Quarry, and

certainly repaid a visit; indeed, if time had allowed, a close and detailed examination would have been made. The chief feature seemed to be, in this section, a bed containing a number of nodules or concretions stained on the surface with iron, but not showing concentric rings when broken. The topmost bed of limestone was false-bedded in places; then followed sand with thin seams of limestone; under these came soft sandstone containing the nodules already alluded to, followed again by limestone. This section was reluctantly left, but time pressed, and the fields were crossed to Brantingham, and from thence it was a pleasant walk to Elloughton.

After tea Mr. B. Holgate, F.G.S., proposed a vote of thanks to Mr. Lyon for his unremitting attention and kindness during the day, and also took an opportunity of expressing the pleasure which the Leeds geologists had had in spending a day with their brethren from Hull. Dr. Walton, F.G.S., seconded the resolution in similar terms; after which Mr. Lyon suitably replied, and invited the combined associations to visit the district again and inspect Weltondale. There was a little time yet to spare, therefore Mr. Lyon invited the members to visit Elloughton Church. This has all been re-built save the tower, which is built of a compact limestone. The tradition goes that the stone for this tower was brought from the ruins of the Abbey of Medehamstead, on the site of the present Peterborough Cathedral, and brought down the Trent to Brough Ferry for that purpose. These rich old traditions are worth preserving. The road had now to be taken at a quick pace for the station, but on the way at the cross roads a halt was made to enable Mr. A. E. Nichols (who had rendered valuable service throughout the day with his camera) to photograph the party.

EXCURSION TO GIGGLESWICK AND LANGCLIFFE,

MAY 18TH, 1889.

Leader, Mr. W. G. PERFECT.

On this occasion the members enjoyed another practical and popular excursion among the majestic scenery of Craven. The object was to visit the Langcliffe Lime Quarries and also the famous Victoria Cave, but it was found impossible to carry out, in the short space of time allotted, the whole of the programme. The Victoria Cave and immediate district will therefore form another excursion of great interest. Saturday was one of those delicious days in early summer when to leave our "wilderness of bricks and mortar" in Leeds, and escape for a brief time to the grand hills of Craven was

like a visit to Paradise. All nature was clothed in the freshest green. The valley of the Ribble looked charming, with its fair pastures bespangled with wild flowers, beautiful and innumerable. The lofty cliffs and scars of Settle seemed grander than ever.

From the station the party proceeded to Giggleswick, where they were received by Mr. W. G. Perfect, the managing director of the Craven Lime Company, who had courteously invited the Association to visit the Langcliffe Quarries, and throughout the afternoon showed the members every kindness and attention. It was thought well that the Museum of the Giggleswick Grammar School should be first visited, and this, by kind permission of the head master, was done. The Museum, in addition to a good collection of well-arranged fossils, contains also the articles found in the exploration of "the most important historic cave in this country"—the Victoria Cave. Remarks upon the cave itself must be deferred until our coming visit, but the President (Mr. J. E. Bedford, F.G.S.), gave a short address in the Museum upon the discoveries, and the various objects were very closely inspected. The curator or custodian pointed out to the members the chief objects of scientific and antiquarian value. Here could be seen the beautiful articles of enamelled jewellery so familiar to us from the coloured frontispiece in Boyd Dawkins' "Cave Hunting." There was one brooch shaped like the letter S, with a front made up of a fine pattern in red, blue, and yellow enamels which attracted much notice, also some harp-shaped brooches, and another with a beautiful pattern in relief upon it. These articles belong to the class termed "late Celtic" by Mr. Franks, and are considered by him to be of British manufacture. The coins of Trajan (A.D. 117), Gallienus, Constantine II., and other Roman Emperors, found in the cave, were carefully examined. There were numerous other articles, as beads, stone "pot boilers," black and red Samian ware, and a quantity of essentials to the feminine toilet in those far off days. Then the bones of the mammalia which entered the cave at different periods were shown; among them being those of the brown and grizzly bears, wolf, fox, badger, horse, pig, reindeer, red deer, the Bos primigenius or Urus, &c.; also of an older type, the cave hyæna, cave bear, Elephas antiquus, Rhinoceros leptorhinus, &c. The "bone of contention" was seen, which has occasioned so much fierce controversy as to whether this supposed human bone could be accepted as evidence of the existence of pre-glacial man in this cave. We were also asked to note a bone harpoon with two barbs on each side, a relic of some fisher in Neolithic times. What scenes may be imagined in meditation upon the contents of this small, but characteristic and valuable Museum! How different the climate, the inhabitants, the animals of Craven have been at various periods! The positions in which the above remains, &c., were discovered in the cave, will be given upon the next excursion.

If time had permitted the quaint Church of St. Alkelda would have been visited, but the object of the day was yet to be accomplished, and hence the way was taken briskly through the fields, on the hill

sides overlooking the Ribble to Stackhouse. The views *en route* were very fine and elicited continued admiration; one was particularly charming, looking back from the brow of a hill with the embattled church tower rising up from among the beautiful foliage surrounding. The Ribble was crossed by a primitive foot bridge, and the eastern bank skirted until we were at the foot of the imposing scars of Winskill, which present a precipitous face to the height of 1,100 feet or more above the level of the sea. The Settle and Carlisle Railway was crossed, and we were now at the immense quarries of the Craven Lime Company (Limited). These quarries present a section truly magnificent in its extent, of the Carboniferous or Mountain Limestone. It is worked right on the face of the Winskill Scar or Rock, and as the crags and rocks tower vertically far above the quarry, the whole view has a most majestic character. It is a prominent feature from the train as it speeds northwards to Carlisle. The bedding is singular. At the north end of the quarry the beds are fairly horizontal, and can be easily worked in ledges; but a fault or dislocation occurs, and the stratification is quite altered. The dip is so different that, to use the expressive term of the workmen, the rock has to be "peeled," and the work assumes a more difficult and dangerous character. Long iron spikes have to be driven securely into the topmost beds, and chains attached to them, to enable the workmen to ascend and descend. The stone is light grey in colour, and very compact. Commercially it is very valuable, as it contains from 98 to 99 per cent. of pure carbonate of lime, and is extensively used in the great chemical industries on the Tyne and in Lancashire. Large quantities too, are despatched to Leeds daily for the purification of the crude gas manufactured at the Leeds Gasworks. About 100 men are kept employed here, so large is the demand for this excellent lime.

Mr. Perfect then explained the system of lime burning, the "Hoffman" kiln being used for that purpose. By this process some parts of the kiln are always in use, and manufacture and deliveries are thus regular. This kiln will turn out about 120 tons of lime per day. The part of the kiln not then in use was entered; the heat was, however, an effectual deterrent to any stay. The party also ascended to the upper part of the kiln, where the fuel is supplied, and the method generally was kindly shown. In one part of the quarry, near to the fault, a large underground cavern exists, but is almost inaccessible from having such a small aperture or entrance. Near the kilns, too, might be seen a good practical illustration of a geological lesson; the water of a small stream, holding carbonate of lime in solution to a large extent, and trickling over some rough and jagged stones, had covered them over thickly with calcareous sinter. Mr. Yeoman also exhibited a few fossils obtained from the limestone in these quarries, particularly may be mentioned a fine specimen of Lithostrotion basaltiformis, Bellerophon, Productus, &c.

The return journey was made to Settle, the road being particularly pleasant at the foot of the lofty scars, with views of the grand scenery of Craven at every footstep.

EXCURSION TO THE "HADDOCKSTONES" & DISTRICT,

JUNE 1ST. 1889.

Leader, Rev. J. STANLEY TUTE, B.A.

The Rev. J. Stanley Tute, B.A., Vicar of Markington, had reported to the Yorkshire Boulder Committee upon the "Haddockstones"—a group of isolated blocks of gritstone in a field about two-and-a-half miles west of Wormald Green Station. The North-Eastern Railway Company, most fortunately, had announced an excursion to Ripon, and kindly allowed a stoppage *en route* at Wormald Green to avoid loss of time. This decided the members to visit the "Haddockstones," and walk from thence to Ripon for return. Professor Miall, F.L.S., &c., chairman of the Yorkshire Boulder Committee, and Professor Hummel, F.C.S., accompanied the members, who were met at Markington by the Vicar, and also by the Rev. E. P. Knubley, M.A., Vicar of Staveley, one of the general secretaries of the Yorkshire Naturalists' Union, and Mr. Dearden, City Surveyor of Ripon.

On leaving Wormald Green Station the members were on a formation rendered familiar to them by recent excursions—that division of the Permian system of rocks known as the Lower Magnesian Limestone. Mr. Tute had kindly informed the members where a good section of this near Wormald Green might be seen, and this was accordingly first visited. It is a little west of the railway station, and is a very instructive section, the quarry being in full work and fresh faces continually exposed. It is capped by boulder clay, which contains large numbers of polished and striated pebbles of Mountain Limestone. One in particular, found by Mr. Bedford, rivalled in brilliancy of polish the efforts of the lapidary. No pebbles of Whinstone were observed in this drift. Next succeeded the Lower Magnesian Limestone, solid and massive with jointings; this is extensively quarried and burnt. In one place, where the beds are somewhat broken in character, fossils can be obtained. Near the base of the section the bedding was of the same nature as we had observed at Burlend's Quarry, near Garforth, having a wavy outline. This, as was said, is a matter for discussion. Does it represent an ancient denuded surface, or has it been effected by cross currents at the time of deposition? The characteristic cavities, lined with bitter spar, were again observed; and our old friend *Axinus obscurus* also was captured and transferred to the collecting bag. The Lower Limestone of the Ripon district has been analysed by Mr. Holme, who gives it as carbonate of lime, 71·125; carbonate of magnesia, 25·625; red oxide of iron and alumina, 1·75; silica, a trace; and water, 1·5.

There is a great quantity of boulder clay in this district, varying in thickness, and this has occasioned the general contour of the surface to be somewhat diversified, rising in some places into mounds or hills. This, as was noted, contains travelled blocks of foreign

origin, as Mountain Limestone; and Mr. Tute said he had also found one or two small pieces of Shap granite and of greenstone. On the other side of Markington, near Cayton Gill, and in a line running northwards, this gives place to a drift in which these travelled blocks are absent, those of fragments of local rocks taking their place. This is termed "the local drift," and is divided from the boulder clay by a well-defined line. Mr. Tute says, in a paper given before the Yorkshire Geological Society a few years ago, "the conviction is forced upon one that here was the edge of an ice cap which covered the hills to the west and was cut off along this line by the glacial sea."

In passing through Markington we were invited to step into the church by our leader, the Vicar, and glad we were to have had the opportunity. The church itself is a comfortable, unpretentious, modern building, but we were struck by the profusion of beautiful carved work in wood it contained. The screen, the pulpit, the reading desk, and the font cover, all drew forth expressions of admiration, but these were deepened when we learnt that this work, so delicate, so beautiful, so artistic, was entirely the handiwork of the Vicar (Mr. Tute). We knew of his ability and work as a geologist, but it was an additional pleasure to find that his zeal and love for his church had in these labours of his for nearly thirty years resulted in such a fine exemplification of true art. On leaving Markington we left the road on the right a little to view a good but small exposure of boulder clay, crammed full of pebbles of limestone, sandstone, &c., of various sizes. These were generally rounded, and many showed striæ. On resuming the road we shortly left it to pass over the fields, and in going through a small plantation came to a small hillock, upon which rested a sub-angular block of Millstone Grit, about a yard across in every direction. This was a true erratic, although it had not travelled far, the block being of the Third or Plompton Grit, the mound of boulder clay, which in its turn rested on the Lower Magnesian Limestone.

A short walk further by field and road brought us to the goal of the excursion—the "Haddockstones." This is the name given to a line of boulders in a field close to the "Haddockstones" Farm, which is about four miles south-west of Ripon. The rocks have given the name to the farm, which was once a grange belonging to Fountains Abbey. They were well known centuries ago, as in the "Memorials of the Abbey of St. Mary, of Fountains," collected and edited by J. R. Walbran, F.S.A., they are mentioned many times—indeed the spelling of the word varies in fourteen different ways. Whether this is an example of the carelessness of our forefathers in such a trivial matter of orthography, or illustrates the evolution of the word, is a subject for argument. The meaning or derivation of the word, we were told, is from the resemblance they bear to a number of shocks of corn, "haddock" being the local term for these. They run in a line from N.W. to S.E. along a ridge. They are angular and present little evidence of weathering, except in one instance which shows the characteristic furrows of the Third Grits caused by weathering. They

are not strictly *in situ*, as the bedding planes are in various directions, and it would appear as if at one time attempts had been made to split them in places by wedges, the surfaces presenting such an appearance as if portions had been forcibly detached. Still, whilst not *in situ*, the ridge upon which they rest is composed of the same rock as the blocks themselves, viz., the Third Grits of the Millstone Grit series known as the Plompton Grit.

There is an old quarry on the side of the ridge where the stone had been got for the erection of the farm buildings, and on the south-west of the ridge were many scattered blocks of the same rock, these being rounded and smoothed. The dip of the rocks on the south-east of the ridge, where we were standing, was S.E. 15 degrees, but some distance away to the north-west the dip was nearly opposite, being N.N.W. 12 degrees. Is it possible these rocks are relics of the denudation of this anticlinal? In that case we should have expected them being on the line of strike. They are close to the line of demarcation alluded to between the boulder clay and local drift. They are not exactly *in situ*, as has been said, but these rocks have a tendency to "creep," or imperceptibly move, in course of time, from various causes. Great care must be taken in determining erratics, to exhaust all other probable or possible means of transport than that of ice, and as this could not be clearly and satisfactorily done in this instance, it was felt that these blocks could not be fairly and legitimately admitted into the happy family of erratics.

And now the geology intended to be done at this excursion had been carried through, and after a rest and chat with the courteous and hospitable farmer of "Haddockstones" (Mr. Spilman), who had given much information to the party during the visit, the way was leisurely taken along the road in the direction of Fountains and Studley. We skirted the base of that prominent landmark known as How Hill, or, as we were informed by a resident, once known as St. Michael's Mount, from a chapel once existing on its summit, which is 575 feet above sea level. According to Walbran, it had a still earlier name, being once termed "Herleshow," probably from the Saxon earl, or proprietor. Now the hoary tower of Fountains was seen emerging from the surrounding woods, and presently we were descending the steep valley of the Skell. It was instructive to observe how this little stream had formed this gorge and cut its way through the Permian escarpment. A short pause to view the fine exterior of Fountains Hall with its picturesque terraces and windows, and then the laborious ascent was made into the Park of Studley.

On entering the Park opportunity was taken to inspect that gem of architectural beauty—the Church of Studley. This, too, richly repaid us, for in addition to our admiration of its beauty of design and brilliancy of colour, the various stones used in the interior for embellishment were attentively examined. The effective Purbeck marble shafts standing out in such relief against the white limestone, the massive font of American marble, the Egyptian alabaster lining of the chancel, the symbolical altar steps of red porphyry and grey

and white marble, and many other beautiful stones of varied hues, all charmed and instructed the geologists who fortunately entered. The walk from thence down the long avenue of stately lime trees, with the towers of Ripon Cathedral closing the grand vista, and the rich green herbage all around, with the peaceful deer browsing thereon, was delightful in the extreme. The path was continued in the cool of the summer's evening over the fields to Ripon, closing an excursion rich in reminiscences, abounding in instruction, and invigorating us physically. It should be added that at the "Haddockstones" a forcible example of the severity of the thunderstorm three days before was seen in a fine ash tree, which had been struck and riven by the lightning.

EXCURSION TO THE HOLME VALLEY,

JUNE 10TH, 1889.

Leader, Mr. J. FIELD.

The geologists in connection with the Yorkshire Naturalists' Union had on Whit-Monday an unrivalled opportunity of studying the geology of the wild and romantic moorland district lying south-west of Holmfirth. The picturesque glens or gorges (locally termed cloughs), each with its little rivulet draining the lofty watershed of the eastern flanks of the Pennines, often display on their sides good sections of those divisions of the Millstone Grit series known as the Third Grits and the Kinderscout. It was to inspect some of these sections and also to obtain a general idea of the configuration of the country that this excursion had been planned. The party had a very practical and able leader in Mr. Joseph Field, of Huddersfield, who has closely studied in detail the geology of the district; and they further had the advantage of the well-known experience of Mr. James Spencer, of Halifax. The temperature of the day was well suited for the arduous ascents which had perforce to be made here and there, as a cool bracing wind prevailed; the fierceness of the sun's rays of the previous week were now neutralised by the grey and leaden clouds which swept slowly across; these were, too, in unison with the bleak and rugged scenery all around.

The party on leaving Holmfirth Station passed through the devious windings of the narrow streets, pausing at the bridge to note the level the waters attained on that fateful day in 1852, when the unrestrained torrents of the Bilberry Reservoir inflicted so much devastation and death on this peaceful valley. The road was now taken from Holmfirth in the direction of Holmebridge, the valley of the Holme being thickly studded with substantial stone-built dwellings, and frequently with busy manufactories. It was a gradual ascent all the way, from 460 feet above sea level at Holmfirth to 610 feet at Holmebridge—on either side lofty grit-capped hills lined the valley. We now left the main road and turned on Brownhill Lane on the way to Ramsden Clough, passing on the way the two reservoirs

recently constructed for the water supply of Batley. All the way the scenery had become grander and more impressive. We were now at an elevation of 800 feet, and before us the dark, imposing heights of Ramsden Edge, Holme Moss, &c., rose steeply to an altitude of 1,600 feet. This bold line of escarpment, in the form of a gigantic amphitheatre, in its regularity seemed like a colossal wall barring all further progress. These heights are capped by the Third or Middle Grits, and as the shales underneath weather away the superincumbent rock falls off at its jointings, and the escarpment continues to preserve its characteristic wall-like character. Here and there the mountain streams cut their way into the escarpments, forming dykes or cloughs, in which may be seen leaping silvery cascades.

Ramsden Clough is a fine section of the Third Grits series, about 550 feet in thickness, overlying the Kinderscout Grit. The latter forms an inlier in the valley, and the lowest bed in the series is quite a conglomerate. Mr. Field then described the succession of the beds composing the Third Grits, and recounted the divisions of the same by the Geological Survey, who for these various sandstones employ the letters A, B, C, and D. The escarpment of Holme Moss alluded to is in the division B. We now descended into Netherby Clough, fording the small stream on our way, and made the steep ascent of Netherby Brow to the quaint and isolated village of Holme, which certainly is "far from the madding crowd," and, for this reason, would be an admirable place for developing scientific studies. It stands in a fine position, about 1,000 feet above sea level, and is surrounded by majestic scenery.

Passing down Fieldhead Lane to Digby Wood, we turned to the left up the valley, past Bilberry Mill, and were shortly on the bank of the famous reservoir of that name. It was a beautiful picture, the placid sheet of water, like burnished silver, right in front the lofty hill of Good Bent, and on the left and right of this hill respectively were the romantic gorges of Hey Clough and Marsden Clough, down which flowed the streams supplying the reservoir. It seemed incredible that this quiet lake should once have been such a terrible engine of destruction, but it was said that the embankment was formerly eleven feet higher than it is now. The shales above the bank of the reservoir were examined, and a thin seam of coal was seen. At Good Bent is the Kinderscout conglomerate. We passed next on Gibriding Lane, and gradually ascended to Green Gate, where we were at an elevation of 1,100 feet. On the way the evidences of the fault which extends nearly from Meltham to Holmebridge were pointed out; a little to the east of Austonley the top of the Kinderscout grit is thrown against a sandstone of the Middle Grits. A little detour was made from the road to visit a quarry in which there is a thin seam of coal in the A sandstone of the Middle Grits. Some small fossils, probably stigmarian rootlets, were here obtained by Mr. Spencer. It is known as the Upper Meltham or White Rock coal. In the sandstone was noticed a large concretion with concentric rings.

From the summit of this quarry Mr. Field detailed the scenery

around us, and at this point was the grandest and most expansive view of the day. To the south were the wall-like heights of Holme Moss, succeeded on the east by a splendid series of step-like escarpments. On Snailsden Moss, near Cook's Study, was one formed by the Second Grits or Flags, to which succeeded those formed by the Soft Bed Flags, the Forty Yards or Loxley Edge Rock, the Eighty Yards Rock and the Elland Flag Rock or Green Moor Rock of the Huddersfield district. Then the Grenoside Rock, on which the erection known as Tinker's Folly is built, was pointed out, also the Rough Rock below Thurstonland. Turning round, the isolated height of Castle Hill was very prominent, and West Nab also was well seen. This lofty hill is capped by the Rough Rock, and, as Mr. Field informed us, there are some remarkable weathered masses of rock strewn about, no doubt from landslips. The time fled rapidly when examining this quarry and enjoying the splendid landscape, and most reluctantly did we leave. We then resumed the road to Holmfirth, having on our right the gorge of Hart Hole Clough, cut into the shales by the tiny beck. The incline was most agreeable coming at the close of the day, dropping from 1,050ft. at the Ford to 460ft. at Holmfirth.

The train was taken to Huddersfield, where, in the rooms of the Young Men's Christian Association, a meeting of the Geological Section was held. Mr. J. W. Davis, F.G.S., occupied the chair, and a brief *résumé* of the day's work was given by Mr. Adamson, F.G.S., one of the sectional secretaries. Among other Yorkshire geologists present were Messrs. Cash, F.G.S., C. Brownridge, F.G.S., B. Holgate, F.G.S., R. Law, F.G.S., C. D. Hardcastle, E. Hawkesworth, &c. It was felt that a most successful excursion had been made. If sections had been few, yet the configuration of the country and the succession of the beds had been ably described in the field, and some remarkable examples of denudation pointed out.

EXCURSION TO HEBDEN BRIDGE AND CRIMSWORTH DEAN,

JUNE 29TH, 1889.

Leader, Mr. JAMES SPENCER.

On this excursion, which had been unavoidably postponed from time to time, the members had the privilege of the valuable leadership of Mr. James Spencer, of Halifax, who knows so thoroughly the geology of the district, and, in addition, can describe in a fluent and lucid manner the different points met with.

Crimsworth Dean is a deep and steep-sided valley, carved by the ordinary processes of denudation (snow, frost, rain, wind, &c.) out of the Kinderscout grits and the Upper Yoredale shales. A finer lesson of the power of denuding agencies cannot possibly be had than in the examination of this beautiful valley. On either side are the lofty and

imposing grit escarpments underlaid by the shales, of which there are in this valley about 500 feet in thickness exposed, In the valley bottom, known as Horsebridge Clough, a small clear stream flows on its way to join the Hebden at New Bridge, and then united, to mingle with the Calder lower down. Up the bed of this stream the party carefully and slowly picked their way from boulder to boulder, searching for those thin beds of nodular limestone, which, from being so highly fossiliferous, have made this locality, as Mr. Spencer termed it, classic ground. Nor was the search in vain. The leader's practised eye speedily found a good exposure, and a rich harvest of fossils was obtained. This deposit is literally crammed with fossils, nearly all in beautiful preservation, among which may be named goniatites, posidonomya, aviculopecten, &c. Mr. Gibson, of Hebden Bridge, was the first to discover this famous deposit. Mr. Spencer pointed out the evidences of a large fault which throws the Grits against the Yoredales.

The party proceeded still further up the stream, until progress in this direction was stopped by the beck flowing over the perpendicular gritstone. This is known as Lumb Falls, and is spanned by the quaint and tiny Horse-bridge; it presents a charming picture both to the geologist and the artist. Mr. Nichols quickly photographed this lovely scene, which so few Yorkshiremen are aware exists at such a short distance. Then the way was taken up the steep declivity to the high road, from which magnificent views of the whole scenery of the district were obtained. At this altitude universal admiration was expressed of the splendid landscape before us, stretching far away to Blackstone Edge. Hamerton says he "likes the long lines of these hills with their endless variety and sweet subtlety of curve." We were charmed to find that these words were not overdrawn. The scenery was delightful in all respects; crag, escarpment, wood, river, and quaint dwellings were all to be seen in the distance, leading one member to say, "Why do Yorkshiremen leave Yorkshire when all this natural wealth of scenery is ever before us?"

After a brief address by Mr. Spencer upon the geology of the district, the road was leisurely taken to Hebden Bridge. On one side we had a steep wooded incline, on the other a busy well-watered and fertile valley, forming, with the old tower of Heptonstall Church opposite, a picture the geologists will never forget.

EXCURSION TO RIPLEY,

VIA CLINT AND HAMPSTHWAITE TO HARROGATE,

JULY 13TH, 1889.

Leader, Mr. ADAMSON, F.G.S.

At the recent meeting of the Yorkshire Naturalists' Union, at Harrogate, the geologists determined that instead of studying the

district to the south-east of that town, they would examine the locality to the north and north-west. By this means three important geological formations could be seen to advantage, viz., the Lower Magnesian Limestone of the Permian system, and the Millstone Grits and the Yoredale rocks of Carboniferous age. Accordingly, instead of alighting at Harrogate with the rest of the party, the geologists proceeded further, to Nidd Bridge, and there commenced their work. They had, however, an experience altogether novel in being without a leader. The Harrogate gentleman who had promised to undertake this duty failed to make his appearance, and so the geologists had at Nidd Bridge to walk over a district entirely new to them, and by study of maps and frequent inquiries of passers-by, to do the best they could. This took time, and at one part of the journey the members lost their way, and had to retrace their steps, causing about two miles of additional walking to be done. The programme was an ambitious one, but it was faithfully carried out, yet the delays alluded to made it very late before the whole of the party reached Harrogate in the evening.

From Nidd Bridge Station we took the road to Ripley, on the way examining that remarkable boss of Lower Magnesian Limestone known as Nidd Rock. It is not only remarkable as being an outlier of the Permian rocks, the nearest position of these being some miles away, but more so as it is almost surrounded by one of these terraces of river gravel, which were formed when the Nidd flowed at a higher level. This is a very fine example of a river terrace. Strangeways, in speaking of these terraces, says that "it is a curious fact connected with them that they all occur just above the 100 contour, which is the maximum elevation of the warp clay; and it would appear from this that they were deposited about the same time, and when the lower portion of the Nidd was under tidal influence as far as Walshford Bridge." The limestone here was soft, thickly-bedded, and yellowish in colour. The rock, apart from its geology, forms a very pleasing picture.

We now passed through the quiet and pleasant little town of Ripley, not having time to bestow more than a passing glance at the exterior of its ancient castle and church, but taking the road to Holly Bank Wood on our way to Clint. The scenery along this road was of a charming character. Our visit to Clint was to inspect a section of the Cayton Gill beds, so inseparably connected with the name of the Rev. J. S. Tute, vicar of Markington. This gentleman had kindly written informing us of this section, and it certainly is a fine one. It receives its name from the good exposures to be seen in Cayton Gill, a few miles north of Ripley. Geologically it belongs to the Third Grits of the Millstone Grit series, and its position is between the the Plompton and Follifoot Grits. It is a hard calcareous sandstone, and is highly fossiliferous, the bed being literally one mass of fossils. There were quantities of Productus semireticulata, spiriferæ, orthis, stems of encrinites, bellerophon, aviculopecten, &c., and one member found what seemed to be a remnant of fenestella. It was a rich harvest for the fossil collectors, and bags began to acquire weight.

There are several other good sections in the neighbourhood, particularly in a quarry at Hampsthwaite and in the railway cutting near the station.

Whilst the party were resting, Mr. Adamson gave an address on the geology of the day's route, describing first the stratigraphy of the whole district, then each bed in detail, with the localities for sections. He also spoke upon the unique geology of Harrogate, and described the great anticlinal to which is due the prosperity of that town. In answer to a question it was stated that the rocks we were now travelling over were the Third Grits, the highest in this district of the Millstone Grit series. Where then were those rocks which we know occur between the Permians and the Third Grits, viz., the Coal Measures, the Rough Rock, &c.? These had been removed by denudation before the Permians were laid down, and although we had had conclusive proof of extensive denudation at Nidd Rock, this was a more remarkable and immeasurably grander example of this familiar geological agency. After other questions had been asked and replied to, the party invigorated again proceeded on their way, passing through charming country lanes to Saltergate Hill, and then to Four Lane Ends. The former hill is capped by the Cayton Gill beds, and at both places there are quarries of the same; but as the one at Clint had been so well examined and time was so limited, it was deemed advisable not to stay.

At Four Lane Ends some of the party thought it best to hurry to Harrogate, but the remainder determined to carry out the whole programme, crossed the Saltergate Beck, which has carved its way through the intermediate shales. An ascent was then made to the ridge north of Oak Beck, where there is a section of the Follifoot Grit, the lowest of the Third Grits in this district, and so named because it is so well exposed on the edge of Follifoot Moor, south of the Crimple Valley. These grits also crop out near Harrogate Gasworks, and it will be remembered that on a former excursion they were noted at Bilton, where the thin seams of coal occur. It may be stated here that the Plompton Grits, the uppermost of the Third Grits, had already been noted by the members during the day, but as these had been previously examined in many other places, it was thought best to pass them over upon this occasion.

We now descended into the beautiful valley of the Oak Beck, where, at the bridge, another halt was called to recline a little on the fresh greensward, and admire the fine wooded scenery of Birk Crag, the joy of many an artist. Here, too, some geology was done, as an opportunity was presented of viewing a section of the Kinderscout Grit, the lowest of the Millstone Grits. These rocks dip sharply at this place about 43deg. N.W. The Kinderscout Grit is now pretty well known to the members from its characteristic included pebbles of quartz, and generally coarse, massive appearance. We soon passed over the great fault which forms the boundary of the Yoredales, and throws the Harrogate roadstone against the Kinderscout Grit. We were shortly, too, on the axis of that famous anticlinal which has

attracted all geologists since the days of William Smith "the father of English geology." This is the extreme end of the anticlinal which stretches across from Clitheroe and Skipton more or less in an easterly direction. As the Government geologists well say—"The Kinderscouts are like a wall on each side of the anticlinal, and afford a key to the whole structure of the neighbourhood." As stated above, these rocks dip at Birk Crag about 43deg. N.W., but on the south side they dip to the Crimple Valley, that is is an opposite direction, or S.E., from 43 to 20deg. These rocks bend round to the fault, and at Starbeck dip to the east only about four degrees. "From this it appears that the anticlinal of Harrogate dies out to the east, and that there is no great anticlinal ridge of Carboniferous rocks below the Permian and Trias."

Time rapidly fled, and the party had no leisure to examine the Boggs Field with its varied medicinal springs, so often described, and of such vast importance and value: therefore we briefly examined the sections of the Harrogate roadstone in the Cold Bath Road. The dip is here in a south-easterly direction, about 20 degrees, but the anticlinal causes it to dip on the opposite side of the little valley, at a steep angle nearly 60 degrees due north. This illustrates the magnitude of the disturbance. This roadstone is extremely well known, and Professor Phillips considered it to be equivalent to the main or 12 fathom limestone of the Yoredales; but, as the Government geologists truly say, "as it occurs at a considerable distance from the nearest undoubted Yoredale rocks, and is only an inlier here at Harrogate along the line of the anticlinal, it is rather difficult to fix its *exact* horizon." However, that it is one of the Yoredale limestones there is no doubt, from its formation and its fossil remains. This limestone has been described as an exceedingly hard silicious rock or a calciferous grit, containing encrinites in great numbers. All geologists know it from its constant presence on the stone heaps by the road side.

The remnant of the party arrived just in time to enable Mr. Adamson to put in a brief report at the general meeting. It was acknowledged that a valuable and a charming excursion had been made, the instruction gained quite neutralising our late arrival, and arousing a desire to see more of this grand geological field.

EXCURSION TO UPPER TEESDALE,

AUGUST 3RD TO 5TH, 1889.

Leader, MAJOR BAINBRIDGE.

The members of the geological section of the Yorkshire Naturalists' Union had a splendid opportunity in their recent visit to Upper Teesdale of studying that remarkable example of ancient igneous activity in our county known as the "Whin Sill," and also of viewing the impressive scenery of the district. The excursion was

somewhat experimental in its character in one sense, as it extended over three days, whilst all former ones had been limited to one day, and the experiment was successful in all respects; more extended observations could be made, more ground traversed, and more important still, the health of the members was thoroughly invigorated by the pure and bracing air of this fine valley. Of course, it would be impossible to investigate such a district as Upper Teesdale in the brief space allowed by one day's excursion, as the various points of interest lie too far away from the rail for return. It is hoped that the experiment named will be repeated and other distant and little known parts of Yorkshire visited.

The chief interest to the geologists in this excursion lay in the inspection of the famous Whin Sill, so well known from the references to and description of the same by various geological writers during the last sixty-five years. The Whin Sill was described by Sedgwick to have been produced by a lateral injection of volcanic matter in a state of igneous fusion, or in other words to be a tabular mass of basalt or ancient lava injected horizontally between Carboniferous strata after their deposition and consolidation. This opinion is shared in by many subsequent writers including Topley, Lebour, and others. Whin is the local name for basalt, but this term is applied in other localities to various rocks of a hard character. Sill is an expressive term, generally used in speaking of the flat piece of stone at the foot of a window. It also gives a fair idea of these tabular beds of basalt sill-like in their appearance and more or less parallel with the sedimentary rocks above and below, between which they have been injected. The Whin Sill can be studied in many parts of Northumberland, Durham, and Yorkshire, but in no place to greater advantage than between Middleton in Teesdale and Caldron Snout, either in the rugged scars on each side of the river, or in the sections made by the denuding process of the mighty waterfalls of High Force and Caldron Snout. At the latter place the basalt attains its greatest thickness, that is, between 200 and 300 feet, and in the lofty precipices in the vicinity may be seen, assuming the columnar structure so characteristic of basalt. It is a far cry from Leeds in Airedale to Middleton-in-Teesdale, as nearly 90 miles of rail have to be passed over, and some necessary but perplexing changes to be made from train to train. However, the ever-changing scenery and the congenial companionship made the journey seem brief, so after crossing the lofty bridge over the Tees at Barnard Castle, and obtaining a passing glimpse of the famous old castle and the splendid woods, we were soon at our terminus, Middleton.

At the station conveyances were obtained, as the party had to proceed some eight miles further up the dale before fairly setting to work, passing through the busy little town above named and the hamlets of Newbiggin and Bow Leys; a short halt was made at the High Force Inn, and at Langdon Beck, a few miles further, we dismounted and crossed over by Widdy Bank to the bank of the river. The scenery had greatly altered as we proceeded—from the broad

valley, with its sides dotted with whitewashed farmhouses and here and there fine woods and charming glens, to a bleak and sterile district, with the river slowly gliding along under the shadow of dark and gloomy precipices. The path, too, was excessively rough, reminding one forcibly of the boulder-strewn walk under the cliffs some years ago at Kettleness. On the Yorkshire side were the high basaltic terraces of Cronkley Scars, with masses of *debris* at their base, and finely displaying the columnar structure alluded to. On the Durham side the tremendous basalt cliffs at Falcon Clints were skirted, and the point was noticed where the heated basalt had come in contact with the underlying limestone (the Melmerby Scar limestone) and had metamorphosed it into a loose granular rock, known generally as "sugar limestone." The grains of this are highly crystalline and have hardly any cohesion with each other, so that it is difficult to obtain a good specimen. On the summit of Cronkley Scars the limestone immediately overlying the basalt known as the "Tynebottom" limestone has this granular character from the same cause. Another stretch of arduous walk brought us to the limit of our journey, the waterfall of Caldron Snout, where the waters of the Tees thunder down jagged terraces of basalt, the foaming cataract being in grand contrast with the black igneous rock. The party ascended the broken sides of the ravine, and crossed the frail-looking plank bridge (nearly 1,500ft. above the sea level) into the county of Westmoreland, thence immediately crossing over the Maize Beck, this time without the friendly aid of a bridge, into Yorkshire again. Here where the Maize Beck enters the Tees is the junction of the three counties, although the exact spot in the bed of the stream would be somewhat difficult to fix upon. The way was now taken along the Yorkshire bank of the river, under the frowning heights of Cronkley, picking our path slowly over the talus at its base and ever and anon pausing to admire the weird grandeur of the scenery around.

Shortly we were upon beds which have occasioned some discussion among geologists, the soft shales known as the Pencil Mill Beds, which were formerly used for the manufacture of slate pencils. These beds are claimed by Messrs. Gunn and Clough, of the Geological Survey, to be Silurian, and they argue that the important fault known as the Great Burtreeford Dyke (which crosses the river near this point, and also crosses the great Teesdale fault) is the cause of these lowest beds being brought up. The total displacement caused by this fault, which crosses over through Weardale to Allenheads, in Northumberland, is thought to be, near the Pencil Mill, about 350 feet. To judge from a specimen of this shale obtained *in situ*, without knowing the position it was obtained from, we should certainly pronounce it to be of Silurian age. In some places veins of quartz run through, and we noted also a dyke of igneous rock crossing the river, and passing through this bed. This dyke seems to be different in character from the basalt we had seen during the day, and partakes more of the nature of a mica-trap. This point was the most interesting we had noticed, as it occasioned some discussion. From thence Cronkley Bridge was

crossed, and the return made to the High Force Inn for rest and refreshment, both grateful to the party, wet and weary as they were.

On Sunday there was no programme, and members could if they choose rest after the fatigue of the previous day, or betake themselves to study some matter in detail still further, or again, by brisk walking in the bracing air, add to their stock of health. Some of the party spent a few quiet hours in the charming and well-wooded grounds connected with the High Force, and thus were enabled to examine more closely the majestic waterfall and the surrounding rocks. At High Force the Tees leaps over the basalt in a direct fall of 72ft. into a deep pool below. The river was much fuller from the rains of the previous night, and the scene was impressive beyond description. The peat-stained waters of the swollen river were hurled with a deafening roar over the ledge, and from the pool rose spray and foam almost to the top of the fall. On the sides of the pool the rushing waters had formed miniature caves in the limestone at the base, and wherever a chink or crevice occurred in the sides of the ravine there some rare and lovely flower was sure to bloom. On the opposite side of the glen rose to a great height moors covered with the purple heather, and here and there a patch of the yellow Potentilla or some other flower equally dear to botanists. The ravine, too, leading to the fall had been planted on its sides with spruce and silver firs, and pleasant and well designed walks intersected the woods, making the approach easy. As stated, the top bed at High Force is basalt; this overlies a bed of shale which from contact is highly indurated, and when struck, has quite a metallic ring; under this again is a thick bed of limestone, locally known as the "Jew Limestone." This is very fossiliferous, being full of corals and crinoids, and is very little altered, if any, by the agency of the basalt.

Monday opened early with heavy rain, which boded ill for the day's programme, as a stiff round lay before the members; happily this cleared off, and on the arrival of a fresh contingent of members by the morning's train, all were ready to begin. For the day's work we had the invaluable leadership of Major Bainbridge, chief of the many mines belonging to the London Lead Company. We should have had the benefit of that gentleman's guidance on Saturday, but that that day happened to be the monthly pay-day of the miners, who flocked into Middleton from many and distant parts of Teesdale and Weardale for that important errand. The full title of the Lead Company is "The Governor and Company for Smelting Lead with Pit Coal and Sea Coal," for which purpose they were incorporated by Royal Charter in the reign of Queen Anne. Previous to this, charcoal had been used for lead-smelting. The programme commenced with a visit to the "blue granite" (*i.e.*, basalt) quarries of Messrs. Ord & Maddison, near Middleton Railway Station. The Whin Sill is here rapidly thinning out, and disappears in the bed of the Lune near Longton. The basalt is extensively quarried for those black "sets" we are so familiar with in the thoroughfares of Leeds, and of which immense stacks were ready for removal. Blake's Stone-breaker was hard at

work reducing the stone to chips for walks and roads, and close by were waggons with the oft-seen words "Leeds Corporation" painted thereon, and waiting for a freight. One gentlemen made a detour to the Lunedale Whinstone Company's Quarries, about a mile S.E. of the Middleton Quarries. He reports that the Whin Sill there is about 15ft. thick, and is capped by about 5ft. of blue ferruginous shale, above this another band of shale about 12ft. thick, and this again by about 15ft. of limestone full of characteristic fossils, as Productus giganteus, and others. He also visited the Greengates Quarry about a mile further south. This is about 1,300ft. above sea level, at the top of Kirk Arran, and he reported that the basalt was distinctly nodular in character, and appeared to be a dyke about 60ft. wide, cutting its way through the limestone from west to east; the stone is darker and denser than that of Middleton, and is said to be very durable.

The remainder of the party proceeded along the road at the base of the great basaltic scars, which form such a striking feature in the landscape on the south side of the Tees, backed again as they are by still loftier heights of limestone. The cause which thus materially alters the scenery of this part of the dale is the great Teesdale fault which throws up the Whin Sill on the Yorkshire side of the river, whilst on the Durham side it is below the surface. Thus, as the leader said, the strata on the north side are in their regular order, but on the south side they are upheaved by the fault some 500 feet. Some very complicated problems and phenomena arise from the manner in which this district has been rent and dislocated by igneous dykes and immense faults. In an old working near the road-side we were shown where iron ore had been worked, but not in profitable quantities; here was strong evidence of the fault, as the face of the limestone could be seen. At Park End Wood—a relic of the old Teesdale Forest—the party divided, and most of the members visited Fairy Dell, and thence climbed to the top of the scars for the view to be there obtained. Holwick Scars were next passed, where the basalt rises in tremendous precipices, whose vertical sides show remarkably well the columnar structure. From thence the fields were crossed to view the Winch Bridge, a seemingly frail structure composed of a few planks of wood hung across the river, whose waters were turbulent enough just below to give us a feeling at least novel. Here the Whin Sill appears in the bed of the river, causing many miniature cascades. The appearance of the basalt there on the north side of the fault shows that the dislocation between this point and Holwick Scars is not so great as we had noted earlier on in the day. We now proceeded further to Holwick Head Bridge (near which the great fault crosses the river), over which we crossed and pursued the road to the High Force Inn, where a hurried tea was despatched, and a still more hurried meeting held. This was absolutely necessary to enable the bulk of the party to reach their distant homes the same evening.

During the excursion there was much discussion as to the com-

position of basalt. The following is an analysis of the Teesdale Whin Sill, made in the laboratory of Dr. Percy. The specimen was taken from Widdy Bank Fell. on the way to Caldron Snout:—Silica, 51·47; alumina, 16·48; protoxide of iron, 8·49; peroxide of iron, 3·61; protoxide of manganese, 0·46; lime, 8·22; magnesia, 5·10; potash, 3·28; soda, 1·18; iron, 0·08; sulphur, 0·09; water, 1·70.

The great Dr. Adam Sedgwick, whom Yorkshire recognises as one of the most illustrious of her sons, drew attention to the geology of High Teesdale more than 60 years ago, and published an elaborate and learned treatise upon the same. This is now extremely difficult to consult, and therefore a summary of his exhaustive observations may be acceptable. He says, in regard "to the embedded masses of trap (commonly called the Great Whin Sill), it appears that immediately below Caldron Snout they are not parallel to the strata between which they are interposed; that between Force Garth Hill and Holwick, where the inferior surface of the trap appears to be nearly parallel to the lower strata, the country is intersected by numerous fractures which have greatly changed the level of the corresponding parts of the different formations; that a fracture passes down the valley and produces a great throw which conceals the trap on the north side of the river; that the trap on the south side of the valley descends among the strata in the form of a great wedge which diminishes in thickness from between 200 and 300 feet to about 12 feet; that near the apparent termination of the Whin Sill a mass of trap breaks out on the opposite bank of the Tees, and is probably prolonged in the form of a dyke, or system of dykes, through the eastern moorlands."

EXCURSION TO ECCLESHILL,

Oct. 19th, 1889.

Leader, Mr. Wm. Cheetham.

The members of the Association had received a courteous invitation from Mr. James Pullan, of Eccleshill, to visit his extensive quarries, and last Saturday they availed themselves of the opportunity thus offered. The weather, however, was extremely unfavourable, and this reduced the attendance to a minimum, for instead of a bright and bracing afternoon, the sky was grey and leaden, and frequently drenching showers fell. However, those enthusiastic ones who braved the gale were met at Eccleshill Station by Mr. W. Cheetham upon his trusty Donald, and also by Mr. Horsfall Turner, of Idle, the antiquarian writer. Mr. Pullan met the party at the quarries, which appropriately are in Stony Lane. Here the Elland flagstone is worked, but a considerable depth has to be excavated before the more valuable stone is reached. Although the first quarry visited was 27 yards deep, yet we were informed the valuable bed of stone

was 19 yards deeper still. There are shales and a great thickness of ragstone, the latter being used for foundations.

In this district are some remarkable and well-defined faults, or rents, or dislocations of the strata. Thus rocks, which before the dislocation were continuous on the same level, now are at various different levels on opposite sides of the fault; sometimes a considerable slip has taken place, in this quarry the "throw" of the fault is about 17 yards. The space between the walls of the fault is about 4ft. wide, and filled up with sand and clay. It well may be understood that in such a fault as this there must have been a tremendous grinding of the surfaces; this immense friction has polished the whole surface of the walls of the fault very highly, indeed such a polish which must be seen to be thoroughly believed. In the face, too, were noticed horizontal polished grooves, which proves also that in addition to the vertical motion, the rocks have also moved horizontally. These polished surfaces of the rock arising from this cause are known by the expressive name of "Slickensides." The heat generated by the great friction alluded to must have been intense, quite sufficient to harden the surface and thus render it more capable of receiving a polish. The party had a somewhat novel experience in being lowered into the depths of the quarry, by crane and bucket. An ascent was made in another part of the same quarry, where the fault was remarkably well seen. The rock here was much broken and jointed. In some places pockets of sand had been found.

Mr. Pullan now led the way to another adjoining quarry, which was descended in the same manner as the first. When safely landed from mid-air on the floor of the quarry, which is 33 yards deep, an opportunity was again offered of inspecting the great fault. The fissure was closely packed with a yellow tenacious and unctuous clay, and in this fissure clay were embedded, in seams four or five inches thick, great numbers of small nuggets of galena or sulphide of lead. These, when broken, seemed pretty good in quality, but they were not sufficiently large or numerous enough to be of commercial value. Mr. Pullan stated, too, that when this clay was dried it was full of crystals, but there was no opportunity on our visit for examining any. It was the opinion that this occurence of galena in the Lower Coal Measures was somewhat remarkable, as the members had previously been acquainted with it, chiefly in the Yoredale rocks and Mountain Limestone, which, of course, geologically, are below. In this quarry was also pointed out one of many large nodular masses strongly impregnated with iron, and from their colour known as "red horse." The quarry had to be rather hurriedly left, because of the heavy rain which now fell unremittingly, and an adjournment was made to Mr. Pullan's office, where a hearty vote of thanks to that gentleman for his kindness and courtesy was adopted, and a general discussion took place upon what had been seen.

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